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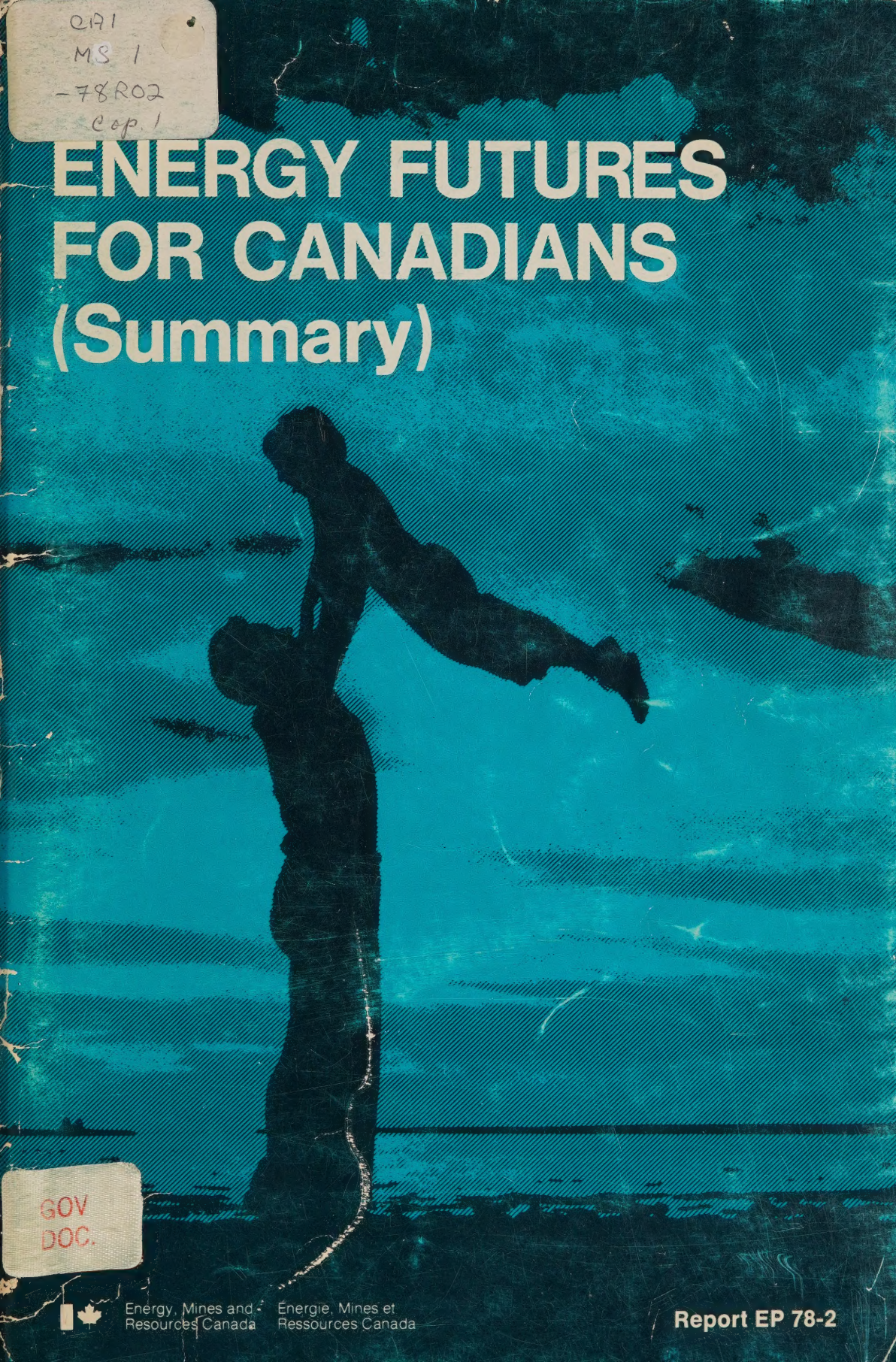
Report EP 78-2

ENERGY FUTURES FOR CANADIANS (Summary)



Energy, Mines and Resources Canada
Energie, Mines et Ressources Canada

Report EP 78-2

ENERGY FUTURES FOR CANADIANS (Summary)

Long-Term Energy Assessment Program (LEAP)

James E. Gander and Fred W. Belaire

Report of a study prepared for
Energy, Mines and Resources Canada

Published under the authority of
The Honourable Alastair Gillespie,
Minister of Energy, Mines and Resources,
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"I am pleased to support the publication of this report and commend it to all Canadians concerned with our energy future. While it does not represent a formal government view of the long-term future nor of the solutions required to meet the challenge, it has been carefully researched and presents a credible base case scenario. In examining the report, however, readers may want to make their own judgements as to alternative scenarios ...

"The value of this kind of report is not to "fix" the long-term future, but to help Canadians choose and develop satisfactory energy futures. Its greatest value, I believe, will be as an important contribution to the public dialogue and debate that must surely take place if we are to make the best choices from among the many alternatives available."

ENERGY FUTURES FOR CANADIANS
excerpt from the Foreword by the
Honourable Alastair Gillespie, Minister
Energy, Mines and Resources Canada

1. FACING THE ENERGY FUTURE

The serious world energy situation which followed the quadrupling of world oil prices in 1973-74 was highlighted in the report, "An Energy Strategy for Canada", published in 1976 by Energy, Mines and Resources Canada. That report, in examining the outlook to 1990, concluded that Canada should strive for a strategy of energy self-reliance. It recommended that Canada should reduce its net dependence on imported oil in 1985 to one-third of total oil demands. That reliance on imports contrasts with a situation, if no action was taken, in which by 1985 net imports of oil might approach 50 per cent of Canadian requirements. A number of policy elements and targets were set down in the Strategy report to achieve that lower reliance on imported oil and a number of actions related to their strategy have been taken. (See Annex 1 to this Summary for a listing of policy elements and targets of "An Energy Strategy for Canada", and Appendix 4 of the Futures report for an outline of current initiatives by the federal government.)

It was also recognized in the Strategy report that an assessment which went only to 1990 could not capture the full impact of the rapidly changing energy situation, or allow fully for the drastic changes which will be necessary in Canada to adjust to a different and a very difficult energy future. The report noted that:

> "What is necessary is to begin now to plan so that such a transition can take place in as smooth and orderly a manner as possible. These longer range issues will be addressed in a paper...that will deal with alternative energy futures beyond 1990."

The report, "Energy Futures for Canadians"(1), in addressing that longer term future (to 2025), does three things:

- assesses the need for action -- by presenting a long-term energy assessment;
- outlines a program of action -- by recommending current programs to assist in the energy transformation; and

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(1) Energy Futures for Canadians, J.E. Gander, F.W. Belaire for Energy, Mines and Resources Canada, 1978; a report of the Long-Term Energy Assessment Program (LEAP).

- seeks to make the program effective -- by outlining an information, communication and participation program to achieve widespread, common perceptions of the energy situation and of the objectives and actions necessary to deal with it.

The Energy Futures report concludes that:

- the world energy situation is likely to deteriorate rapidly after 1990;
- the strategy of self-reliance for Canada should be pushed even harder, and become a policy of sustainable self-reliance in which imports of oil are reduced by the year 2000 to a much smaller part of energy supply; no significant dependency on imported oil would remain beyond 2000, and sustainable but changing Canadian supplies would be balanced by changing patterns of energy demand;
- the energy changes will require a substantial transformation in the use of energy to be introduced progressively from now on; and
- the necessary adjustments require a major transformation in Canada's energy system, with substantial implications for the economy and for Canadian society; no satisfactory adjustments can be made unless even greater action is taken from now on by all Canadians. In that respect, the energy future is urgent.

The current energy situation in Canada and abroad, and many short-term forecasts, seem to deny the urgency or even the necessity of special, comprehensive action. The growth in energy demand has moderated (principally in keeping with the higher energy prices and slower economic growth); conservation measures are being introduced; alternative energy sources are being investigated; new oil supplies are coming on stream in Alaska, the North Sea and Mexico; world oil supplies, in total, are more than able to meet current demands, and oil prices have stabilized or, indeed, declined in real terms (in comparison with price increases more generally). These developments justify a sense of optimism about our ability to meet energy requirements over the next few years. If world economic performance continues to be unsatisfactory for many years, the available energy supplies will adequately meet requirements well into the 1990s, by which time at least some longer term adjustments will have been made. However, in a study concerned with adjustments for the years beyond 1990, a sense of complacency is not justified. That is especially true if one accepts the necessity to provide energy for a much improved economic performance and for enhanced personal and social well-being in the industrial world and in the developing countries. Exten-

sive moderations in demand and changes in the patterns of demand are required. Substantial increases in energy supply, both from conventional and from new sources, and changes in patterns of energy supply will require a host of long-term, complex programs. The changes in demand and supply will combine to impose upon Canada and the world processes of adjustment and transformation which will be difficult in the extreme, even if we take advantage of all available lead time between now and the end of the century. Looking at the long-term future, therefore, there is no reason for complacency and no reason to delay programs and processes which will build extensively, from this time forward, on current plans and programs in all parts of Canada.

The emerging energy situation, as described later in this Summary, will inevitably impose severe constraints and strains. Without clear perceptions of the possible magnitudes and direction of the long-term changes, and of actions to deal with them, the future of Canadian society could be unduly fettered and even disrupted by avoidable energy imbalances. The costs of preparing in advance for the necessary transformations are small. The costs of not acting in advance could be immense and be borne for generations.

The third dimension of time

The rapidly changing future energy situation will profoundly affect Canada and the world whether or not programs are implemented to deal systematically with it. The choice, therefore, is whether we try to put in place well coordinated programs to meet long-term, indicative energy targets, or whether we operate on much shorter time horizons, often under crisis conditions. No rigid or fixed targets and programs will be possible, but indicative targets and adjustable programs can be established within a comprehensive, consistent approach. We can use the lead time, with flexibility and resiliency, to evolve satisfactory energy programs. It is not, for example, just a matter of installing one more electricity generating plant or another oil sands plant, or one more pipeline, or a home insulation program -- important though these measures are. We are called upon to anticipate longer-term needs -- for example, 25 more nuclear plants, 12 more oil sands plants, an array of renewable resources and of structural changes in demand, a national space heating plan, and many other requirements. All of these changes are to be put in place within the same 25-year span of time.

What is required is not just a different magnitude of planning and of project implementation; but a different kind of approach. A different perception is called for regarding the approach to our

energy future. If the long-term adjustments are to take full advantage of the remaining lead time, and are to avoid unnecessary government intervention in the form of allocations, rationing and controls, the additional efforts must be started right away and involve as many people, acting in concert, as possible. The real challenge in facing the future, therefore, is to achieve a sufficient measure of agreement on the gravity of the future energy situation, and on the necessary targets and programs so that concerted action can be taken. This is a human resource problem, not a physical resource shortage. The approach requires the explicit introduction into our planning and programs of a third dimension of time -- the long-term future in preparation for which we can continuously and progressively introduce major changes.

Governments, particularly the federal government, undoubtedly will have increasing responsibility to define the national purpose, to initiate and coordinate activities -- in short, to harness the national will. However, industries and other groups in society also have increasing responsibilities to initiate and to implement programs. The magnitude of the total energy-related tasks is sufficiently great to occupy all available effort.

National Energy Program

Thus, a National Energy Program is called for involving all Canadians acting within a wide range of initiatives. The principal features of the National Energy Program are:

- considerably altered patterns of energy supply and use, including substantial structural changes in the economy and in communities;
- extensive re-organization of institutions, regulations and management procedures;
- concerted action on the processes and factors of adjustment such as prices, costing, fiscal policies, financing, investment, ownership and control; manpower and community requirements; technological innovation, environmental protection, land use, public participation and other social factors;
- a National Energy Information and Participation Program.

The National Energy Program is designed to ensure that we exploit the energy we can have in the future, not try to rely on supplies which we have been accustomed to have in the past, but which will no longer be available in sufficient quantity, or otherwise will not be the optimum approach.

The objective of the National Energy Program is sustainable self-reliance in energy. New energy balances so struck would support satisfactory economic performance and enhanced individual

and social well-being from now through 2025. This is not an isolationist position. International activities pertaining to Canada's energy future will increase, not decrease. (See Figure 7.)

The keystones are Reduce and Replace -- reduce substantially the rate of growth in energy demand, especially the demand for oil, and replace imported oil with Canadian energy resources. Extending the perceptions of the Strategy Report, the new balances will be based on:

- an even lower growth in energy demand and a change in energy end-uses to match future supply capabilities;
- a much lower market share for oil;
- a sustained or increased share for natural gas;
- a substantially increased share for electricity;
- the maximum practical use of renewables and byproduct energy; and
- new institutional and management arrangements to deal with the long-term future.

New and long-lasting economic and social opportunities can result from an imaginative, bold approach to the energy transformations. Even though many of the energy transformations and many of the opportunities will be realized at the local and provincial levels, maximum benefits will only be gained when the programs are coordinated nationally. Energy linkages might be to Canadian unity in the decades beyond 1980 what the rail links were one hundred years ago. The transformation of Canada which accompanies the new energy era might be as dramatic as that introduced by the railroads.

Principal long-term energy targets

The principal targets are:

(1) Reduce the growth rate in energy demand for the period 1978 to 2000 to one-half the 5.3 per cent historic rate; cut the growth rate in energy demand to at least one-half again for the years 2000 to 2025.

(This requires, not just further conservation and increased efficiency in current patterns of use, but greatly altered patterns of use and supply of energy in ways which support satisfactory economic performance and enhanced personal and social well-being. What are seen as structural rigidities in the short-run offer opportunities for change in the long-run.)

(2) Reduce the share of oil from 46 per cent of primary energy to about 30 per cent by 2000 and 25 per cent by 2025, and reduce the share of imported oil to not more than 10 to 15 per cent of that lower oil share (a dependency of not more than 400 000 barrels a day by the year 2000); reduce oil imports to negligible amounts by 2025.

(3) Increase Canadian oil production by about 50 per cent by 2000 and sustain that level to 2025 -- principally from oil sands and heavy oils (with any frontier or other new discoveries worked in).

(This would require possibly 15 oil sands and heavy oil plants by 2000, staging one new plant every 18 months -- an extremely difficult, perhaps unachievable objective, but a measure of the difficulty of achieving sustainable self-reliance whatever course is chosen.)

(4) Increase natural gas production by at least one-third by 2000 and sustain that production or increase it further to 2025 -- permitting a new gas wedge, based on an assured supply, to penetrate the markets of central and eastern Canada to reverse the growing dependency on foreign oil.

(5) Increase coal production four or five times by 2000, with further substantial increases to 2025; extend the use of coal into many new applications.

(6) Increase the market share of electricity so that electricity is providing at least one-half of total primary energy compared with about one-third at present.

(7) Supply at least 5 per cent of primary energy from renewables (other than hydro) by 2000, and 10 per cent by 2025 -- the equivalent of about 400 000 barrels of oil a day in the year 2000, and one million barrels a day by 2025.

(8) Ensure, if possible by 2000, and from then on, that at least one-third of the energy requirements of central and eastern Canada is provided by energy resources indigenous to those regions, on a sound economic basis, and that the remainder comes essentially from the energy-surplus regions of Canada (including the frontier and coastal regions).

(9) (a) energy prices in Canada should be at the equivalent of the world price of oil (a continuation of current policy), at least until costs of energy production in Canada, for supplies adequate to meet long-term Canadian requirements, are below world oil price equivalence; and

(b) price differentials should encourage in each region of Canada the interfuel substitutions necessary to sustain satisfactory energy balances.

(10) Ensure that energy transformations are used as the basis of new industrial, employment and international trade opportunities and to support Canada's contribution to developing countries.

(11) Bring into place energy reports, accounts and budgets, and a system of communication to permit Canadians to relate their actions to shared national energy objectives.

A National Energy Program is a means by which the energy adjustments which are being initiated by people in all parts of Canada are coordinated and evaluated in terms of the objectives, the indicative targets and the changing energy situation in Canada and around the world. It is a process for increasing the consistency and completeness of the adjustment, not of imposing a large measure of central control. A coordinated, long-term program, public understanding of it, and public support for it, are essential to a successful process of adjustment.

Making the energy adjustments

A large number of factors will determine whether satisfactory adjustments can be made to Canada's energy system over the coming 25 years and in the years beyond that. Each of these factors of adjustment requires substantial innovative activity in its own right, and a great effort will be required to ensure consistency among them in the pursuit of energy, economic and social objectives. Examples of actions among the various factors of adjustment include:

- pricing policies in which oil, natural gas and electricity prices are based in the first instance on sound economic costing principles; tax and fiscal incentive provisions which would help to establish differentials to encourage energy substitutions in demand and supply, allowance would be made for external costs and benefits -- for example, to support greater use of electricity, natural gas, co-generation;

- innovative financing schemes which ensure adequate financing for essential programs -- for example, for improved housing, in situ oil sands production, increased use of natural gas with supporting reserves, and a wide range of renewable resource programs; a Revolving Investment Fund might be one financing scheme used;

- environmental, land-use, health and other social programs would deal comprehensively with long-term energy systems; comparative assessments would be made in advance of program implementation, thus, permitting preferred environmental and other social programs to be adopted -- for example, assessments of full-scale oil sands and nuclear energy programs;
- jurisdictional agreements, institutional, regulatory and management changes would be specifically designed to eliminate constraints and to support preferred and essential energy programs -- for example, to encourage the use of indigenous resources in energy-deficit provinces, and new, experimental building and vehicle designs;
- a much broader approach would be taken to technological innovations; the greatly expanded efforts would include, besides basic research and development (R&D), demonstration and deployment (RDD&D); these programs would deal with gaps or constraints wherever they occur in the implementation of an energy program (for example, to meet public perceptions of the hazards and risks of nuclear power);
- adoption of new designs and support programs would encourage structural changes in housing, other buildings, transportation, communities, industrial and commercial equipment and processes; these programs would be designed not only to increase energy efficiency, but also to support the transition to new energy demand-supply balances -- for example, by means of new transportation systems, both urban and inter-urban, new industrial processes and new industries, new urban designs;
- manpower, support-industry and infrastructural changes would support the transformations in patterns of energy supply and demand -- for example, new manpower training and incentive schemes, a comprehensive approach to supplying materials, equipment and community services for entire energy programs; and
- a full communications and participation program would be put in places as outlined in the Recommended Programs.

The adjustment process will be more difficult than that of the past 25 years because:

- changes in energy demand and supply will be toward less preferred rather than more preferred patterns and will be a constraining factor, not a strongly expansionary one;
- energy costs and prices will be increasing substantially, at least beyond 1990;

- for many adjustments, the processes of transition are at a very early stage (e.g., renewable resources, increasing energy efficiency, structural changes in demand);
- risk and uncertainty will be much higher during the rapid transitional processes in the years ahead; and
- the need for concerted, coordinated actions is much greater.

In the last analysis, the skill with which we manage the adjustment process will determine the success or failure of Canada's future energy program.

Alternative futures

This report is intended to fuel, not pre-empt, a wide-ranging dialogue on Canada's energy futures. Widespread discussion and debate over the perceptions and conclusions of the Energy Futures Report will help Canadians to reach agreement on the appropriate energy programs. The report focuses on a single but plausible energy future to demonstrate the serious nature of the problems we confront. In assessing possible alternative futures, the report concluded that none of the alternatives offered an easier or more satisfactory solution than that on which the report focused. Policies and courses of action might differ appreciably from one approach to another, but the essential problems of adjustment were not reduced. To reject the admittedly very difficult approach of this report is not to solve the problems of the energy transformations. It simply is to require that some other programs probably at least as difficult be substituted. There are no easy solutions. To devote less effort to the task would almost certainly be to increase economic and social stress.

The energy programs themselves do not offer a master blueprint for society. Energy decisions must be fitted into the whole array of other decisions -- economic and social in Canada and internationally. There is need to react dynamically to rapidly changing events not just in energy matters but also in the broader economic and social spheres as well. The economic, personal and social aspirations of Canadians are paramount. The energy transformations are to serve those objectives, not control them.

The main policy elements of the report are designed to accommodate alternative approaches and the continual impact of changing circumstances. In brief, the five main policy elements, as outlined later in Section 5 are:

(1) Transformation of end-uses.

(2) A consolidated energy supply.

(3) Facilitating the adjustment process.

(4) Realizing the economic and social opportunities.

(5) Establishing an information program and public participation.

The provinces and the National Energy Program

Provincial governments exercise considerable authority over energy resources, taxation, financing, rates of development and provincial energy utilities. They also regulate or greatly influence many aspects of energy use (urban and industrial development, provincial transportation systems, and so on). New national energy balances will be expressed ultimately in terms of satisfying local and provincial needs. Thus, an examination of Canada's energy future and of the appropriateness of particular energy balances to Canada's economic and social future must centre to a great extent on provincial priorities and the diversity of circumstances which are to be found across Canada.

The objective of reducing the growth rate in the use of energy applies to all parts of Canada. The objective of "backing out" imported oil is especially relevant to the Atlantic Provinces and Quebec, although it could also apply within a few years to Ontario as well.

Three provincial or regional objectives follow if energy self-reliance is to be achieved for Canada:

- reduce our eastern exposure by avoiding any further increase in the dependency on imported oil in the Atlantic Provinces and Quebec, and prevent dependency on imported oil in Ontario and the other provinces;
- reliance on imported oil in central and eastern Canada should be essentially eliminated by the year 2000; and
- at least one-third of the energy requirements of central and eastern Canada should come from sources indigenous to those regions, and the remainder from resources available from the energy-surplus regions of Canada.

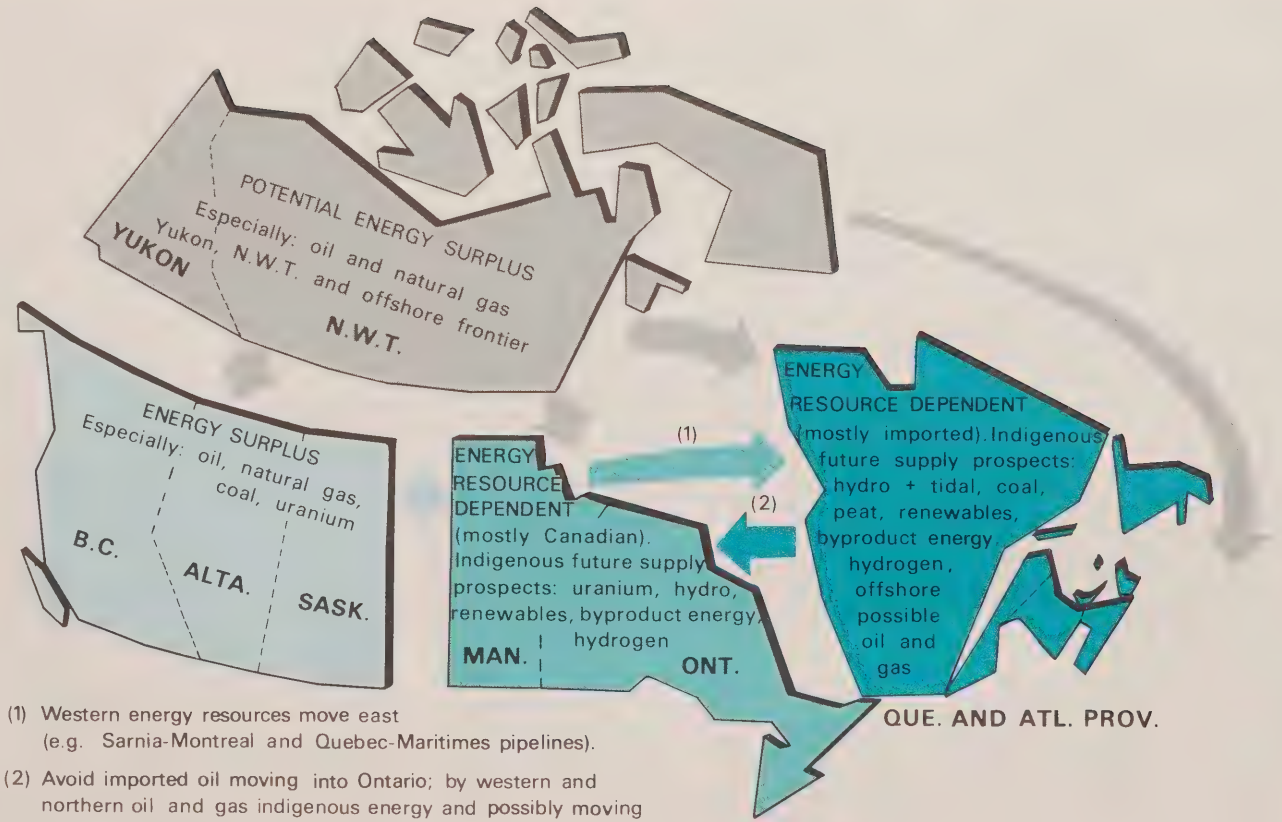
It is readily apparent that the energy-deficit regions of central and eastern Canada can gain from a policy of national self-reliance in energy. However, the energy-surplus provinces and regions can also gain. For them, the principal gains will come from the income generated by the sale of energy resources and energy-intensive goods and services to other parts of Canada and abroad, under nationally promoted marketing programs. The energy-surplus provinces and regions can also gain from the sale of equipment, supplies, technology and services complementary to the energy, and energy-intensive industries.

Federal government initiatives are essential if satisfactory energy balances are to complement industrial, employment and regional policies. Without national coordination, the many conflicts and gaps within provincial energy programs could work to the disadvantage of all. Energy developments in frontier areas, which come mainly under federal jurisdiction, will be coordinated within a National Energy Program. Interprovincial pipelines and other transport and storage systems are another integral part of the national energy approach. Federal initiatives can also greatly contribute to the international marketing not just of energy resources but of energy-related goods and services. Federal participation will also be evident in energy financing, both domestic and international, and in other international relations.

The energy initiatives of the federal and provincial governments cannot be separated from Canada's economic and social development in which a coordinated, national approach is essential. Moreover, the whole range of activities in the private sector must work within the combined impacts of the federal and provincial frameworks. The private sector activities include virtually all of the energy supply industries, the energy users, financial institutions, community and manpower activities, and so on.

Thus, a National Energy Program is much more than just an "add-on" to provincial programs. A National Energy Program is a matter of public perception. It rests upon a recognition of a broad, national interest -- that mutually beneficial actions can be taken within a comprehensive and an expansive view of Canada's future. Provincial differences in priorities can pose a national threat unless viewed within a national perspective. Even with our best national efforts the margin for success is very slim. The hazards would be greatly increased by a fragmented approach to our energy future.

Figure 1 illustrates the energy-deficient and the present and potential energy-surplus regions of Canada. Quebec and the Atlantic Provinces at present rely upon imported oil for more than 70 per cent of their energy requirements. Ontario relies on imported coal and on oil and natural gas from western Canada for most of its energy resources, and could become dependent, in part, upon imported oil if Canadian supplies are not forthcoming in adequate amounts. The principal objective of achieving energy self-reliance is, therefore, to meet, from Canadian sources of supply, the future energy needs of central and eastern Canada. The objective will require that intensive efforts be made to develop the indigenous energy resources of those regions (along sound economic lines), and alter patterns of demand to use fully those available resources. An indicative target is that central and eastern Canada should meet not less than one-third of its



(1) Western energy resources move east (e.g. Sarnia-Montreal and Quebec-Maritimes pipelines).

(2) Avoid imported oil moving into Ontario; by western and northern oil and gas indigenous energy and possibly moving East Coast + East Arctic oil and gas into Ontario.

Figure 1. Illustration of regional energy supply position.

energy needs by 2000 from its own resources, and continue to do so through 2025. An attempt to move closer to one-half of their needs might not be over-ambitious by 2025. The balance of the energy requirements of central and eastern Canada would come principally from western Canada and the frontiers, possibly also involving some exports and imports of energy.

A critical consideration is the provision of sufficient incentives to the energy-surplus regions to ensure that they have reason to participate fully in the transnational, west-east, north-south movement of energy resources within Canada. The major incentives to the energy-surplus regions are to be found in economic and social advantage. Competitive prices must be paid for the energy, and cooperation and support given to the economic and social priorities of energy-surplus provinces and regions.

Some transfers of wealth, population and well-being can be expected in favour of the energy surplus regions of Canada, just as they have favoured the oil-surplus regions of the world. However, within Canada, those transfers need not be seriously disturbing to the rest of the country. The substantial impetus arising from energy-related activities in all parts of Canada can result in widespread economic and social benefits, particularly if approached within the context of a National Energy Program.

2. THE WORLD ENERGY SITUATION

The change from 1973 to 1978

The shock of a quadrupling of world oil prices in 1973-74 was the signal that a fundamental change had occurred in the world energy situation and that very serious long-term problems existed. The world had crossed the threshold from cheap and abundant energy to high-priced and much more constrained supplies. The end of the era of abundant low-cost oil marks a transition in world history perhaps as great as any other single event.

Although the 1973-74 oil situation primarily resulted from the actions of the Organization of Petroleum Exporting Countries (OPEC), it represented an important and fundamental change. In the mid-1950s, the United States had produced nearly one-half of the world's oil and was a major factor in price setting. By 1973, the United States supplied only about 20 per cent of world oil, and imported from OPEC countries 35 per cent of its own requirements -- a dependency on imported oil that has increased significantly since that time. The OPEC countries now produce well over 50 per cent of world oil supplies, and the entire western industrial world (including Japan) is heavily dependent on those supplies. Oil typically accounts for well over one-half of the industrial world's energy at point of use.

Many disturbing impacts followed from the initial shock of higher oil prices. All energy prices tended to increase substantially; balance of payments problems in international trading became common; inflationary pressures were increased and the forces making for economic recession were greatly strengthened.

Both the industrial countries and the developing countries have begun to devise measures to reduce their vulnerability to the growing dependency on oil. Measures of energy conservation, increased efficiency in use, some attempt to switch to other forms of energy, and provisions for emergency allocations and shared supplies can be expected to have some significant effect. However, the measures so far taken and planned are unlikely to ease appreciably the basic world dependency on OPEC oil. The rate of growth in demand for that oil over the next 15 or 20 years might be slowed appreciably from what it otherwise would be, but the basic world dependency on OPEC oil is likely to remain high, or increase further unless much more drastic actions are taken.

The 1985 Syndrome

The difficulties of getting concerted actions and strong public support for them to reduce dependency on imported oil in most countries of the world is seriously blunted by what is here referred to as "The 1985 Syndrome". Reductions in the rate of growth of demand for oil, resulting in large part from general economic recession, create an illusion that the previous crisis was a temporary phenomenon. That illusion is heightened because of the increase in oil production among OPEC countries, the measures which have been taken to reduce slightly the dependency of industrial countries, and the advent of North Sea oil and natural gas, Alaskan slope oil and natural gas, and significant oil discoveries in Mexico. Given that combination of favourable factors, any examination of the world oil situation to 1985 might conclude that there is no longer a serious energy problem. The danger lies in taking the analysis only to 1985. Beyond that time, many factors combine to indicate a condition which will deteriorate rapidly, and could well catch the world unprepared.

Longer term world energy future

World energy demands over the longer term will reflect in large part the increase in world population and wealth and the distribution of that population and wealth among the regions of the world. Some features of population distribution are given in Figure 2.

The industrialized world can be expected to decline as a proportion of total population. The Indian sub-continent, Africa south of the Sahara, Central and Latin America and the Caribbean are expected to experience the most rapid increases. The Middle East (including Iran) and North Africa, the principal oil producing region, which had a population less than one-half that of Western Europe in 1975, is expected to be nearly 80 per cent as large as Western Europe in 2000, and about one-third larger in 2025. Further demographic factors making for increased energy consumption are the trends toward greater urbanization and the greater energy-intensity of the activities of both the urban and rural populations.

The shift in the share of the world population to the developing countries is accompanied by a significant but less than proportional shift in the production of wealth (Figure 2). The OECD share of gross domestic product is reduced from nearly two-thirds of the world total to less than 50 per cent by 2025 while that of the Middle East and North African countries, China and other developing countries increases accordingly.

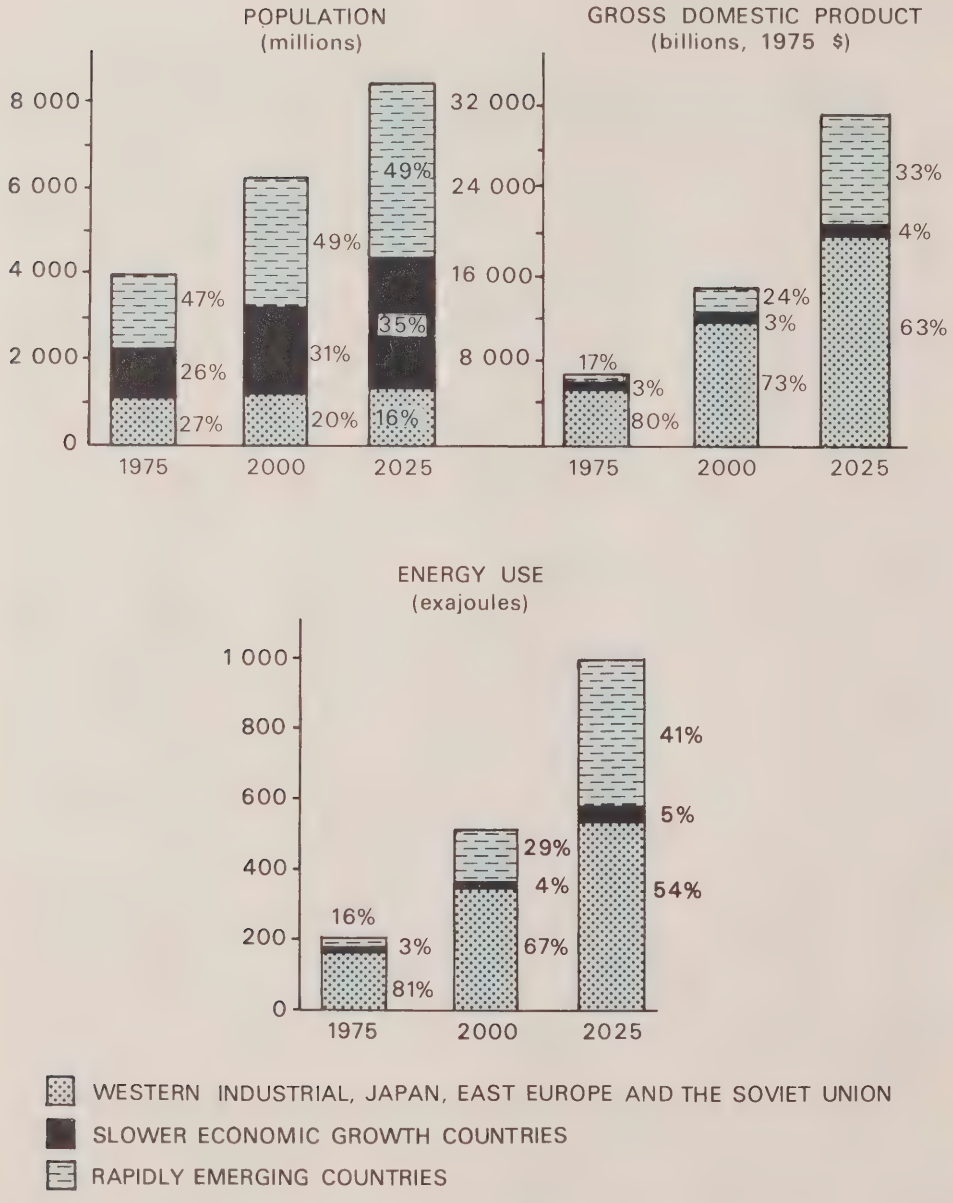


Figure 2. World population, gross domestic product and energy use.

A somewhat similar change takes place in the regional use of energy (Figure 2). The OECD share is expected to decline from about 60 per cent in 1973 to just over one-third by 2025, with

the Middle East, North Africa, China and the other developing countries becoming dominant. Even by the year 2000, the OECD countries are expected to use less than one-half of the world's energy. Eastern Europe and the USSR hold a fairly steady one-fifth of energy consumption, mostly from their own resources, but with the possibility of requiring imported oil by the turn of the century.

Thus, the share of world population, income, wealth and the use of energy all shift proportionately toward the developing countries. Although the western industrial world will face growing competition for energy from the developing countries, its own population and wealth also continue to increase, thereby adding to its own energy requirements.

Before the year 2000, the production of oil from the North Sea and the Alaska slope is expected to have declined appreciably, as will oil production in the OPEC countries as a whole. Nevertheless, the strategic role of the OPEC countries as suppliers of world oil increases sharply unless the world's reliance on oil is substantially reduced.

Figure 3 illustrates the peaking and decline of world conventional oil production and remaining proved reserves.

It can be seen from Figure 3 that world oil production might peak at about 80 million barrels a day in the early 1990s, increasing from the nearly 60 million barrels a day now produced. Beyond the early 1990s, oil production declines until, perhaps by 2010, world oil production is back to about current levels of production even though the world's energy preference would be to use much greater quantities of oil.

The increases in world energy demand and the peaking and subsequent decline in world oil production pose a very threatening problem. Total world energy requirements might be the equivalent of more than 300 million barrels of oil a day (MMboepd) by the year 2000 (a rate of growth of about 3.7 per cent a year). If one-half of those requirements continued to be oil, 150 million barrels of oil per day would be required, more than twice the anticipated oil production at that time. If the OECD countries continued to use one-half of the world's energy, their oil requirements alone would exceed the world's oil productive capacity. Those preferred demands for oil would, at the same time, be confronting rapidly increasing demands from the developing countries and possibly from the Soviet Union and Eastern Europe. Even if this assessment were to overstate the situation by a factor of two, the world would face a potentially highly disruptive energy adjustment in the coming 20 years.

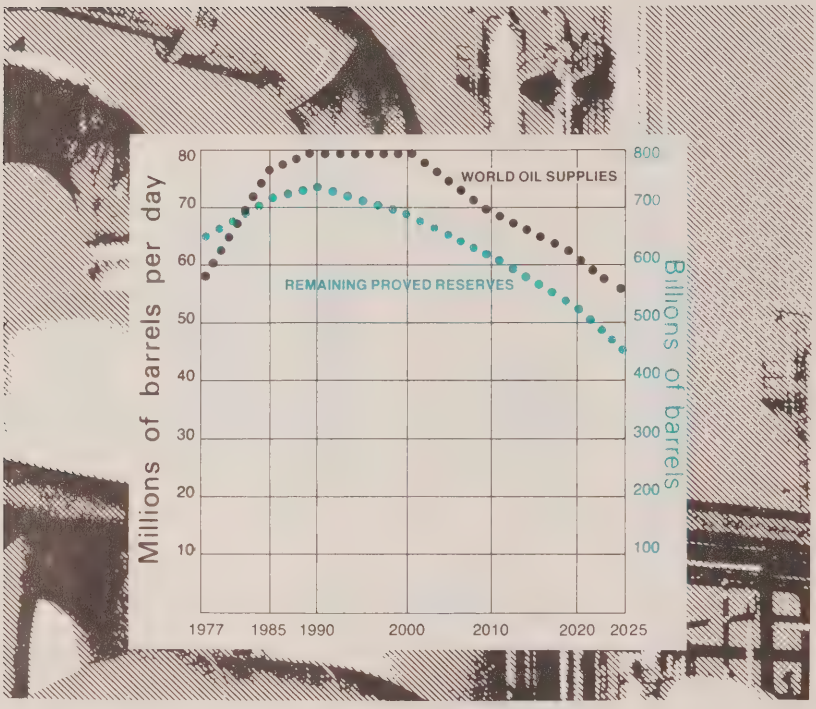
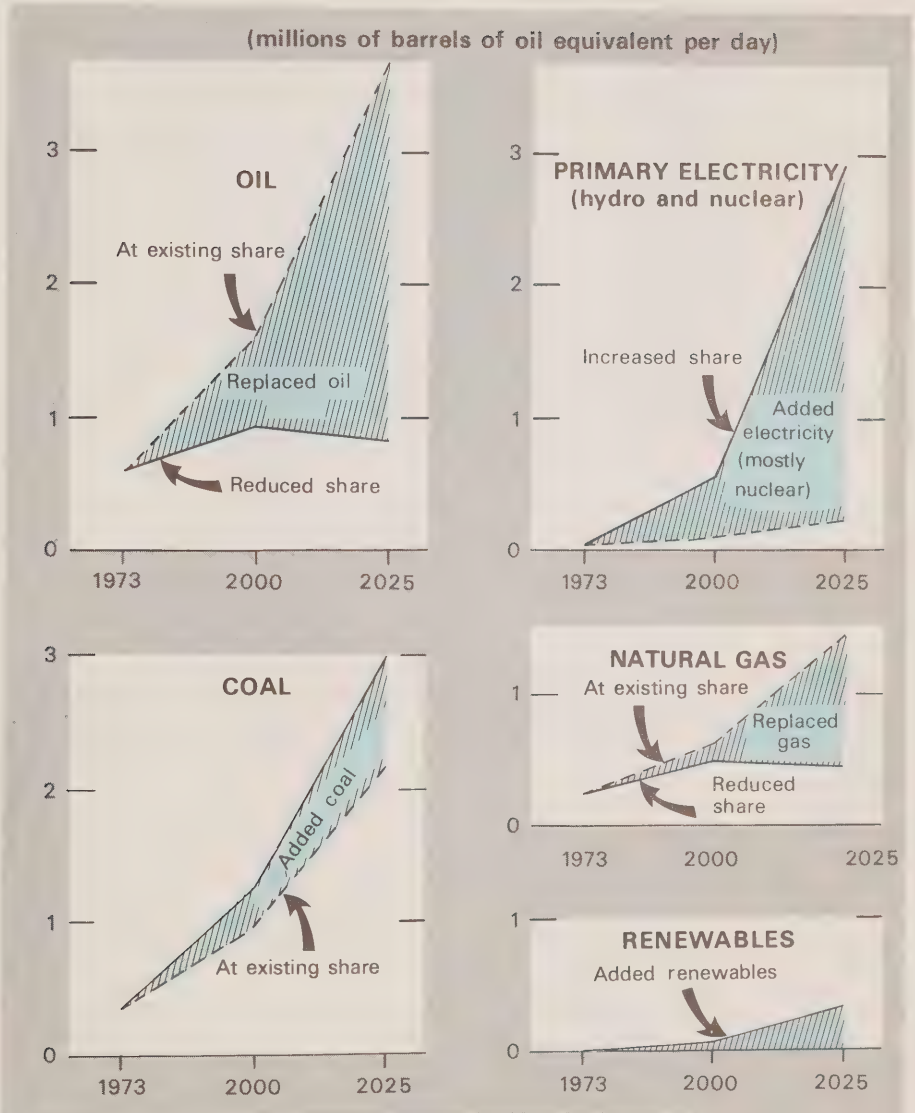


Figure 3. World supply and reserves of conventional oil 1977 to 2025.

Thus, even when allowance is made for new discoveries, oil sands and shales, and enhanced recovery techniques, major adjustments in world energy systems away from such heavy reliance on oil must be made prior to the year 2000. Those adjustments will then continue beyond 2000. The substitution of electricity, coal and renewable resources for oil and natural gas is shown in Figure 4. The pattern of change is illustrated in Figure 5 where the declining share of oil is evident.

The lower share of oil, shown in Figures 4 and 5 for the years 2000 and 2025, is a forced reduction in the use of oil, not a preferred reduction. It is made necessary by the sheer inability to produce all of the oil that people would prefer to use. There is no reason to expect that the forced, wrenching away from oil will occur automatically or smoothly. It contains a potential for massive disruptions on a world scale. Although the rate of growth in energy demand is postulated to be lower than in the past



CHANGING MARKET SHARE (per cent)

	1973	2000	2025
OIL	49	28	11
NATURAL GAS	19	15	6
PRIMARY ELECTRICITY	3	16	39
COAL	29	38	40
RENEWABLES	—	2	4

Figure 4. World substitution for oil and natural gas.

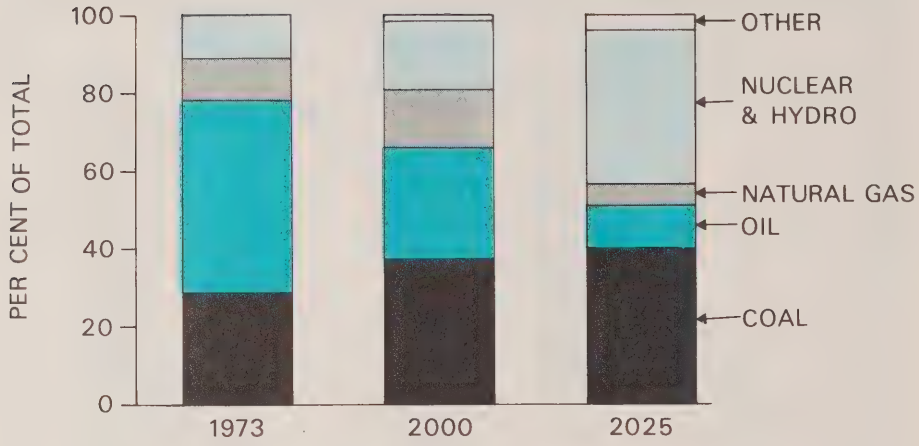


Figure 5. World primary energy production by source.

25 years, an even lower rate of growth in energy demand would ease the burden. The lower rate of growth might occur, but a severe reduction would bring with it economic and social distress.

The pressures of increasing world demand on limited oil production are expected to be evident well before the year 2000, and to result in substantial further increases in oil prices -- at least doubling in real terms (beyond the rate of increase in prices generally) before 2000. However, these price signals will not be received soon enough to lead to an early start on the necessary, large-scale adjustments (which should already be underway). Even more disturbing might be serious interruptions in supply, or inabilities, from time to time, to meet particularly heavy pressures of demand. Considerable economic and social disruption could result unless major adjustments are made. On a world scale, natural gas production is expected to follow a similar pattern to oil but with some delay. Coal and nuclear power are seen as the principal sources of the required, additional energy, with renewable resources and byproduct energy also increasing appreciably in use. However, the increase in use of each of those sources of supply faces serious difficulties as well.

World energy trade

World energy trade is expected to increase substantially between now and 2000 and 2025, driven by the increasing demands of the industrial countries and the developing countries. Because of the sheer difficulties of providing and transporting such large quantities of resources, the various countries and regions

might be forced to try to achieve greater self-reliance in energy from whatever resources are at hand. To achieve further substantial reductions in energy use would also require major energy transformations.

World trade in energy, as shown in Figure 6, is expected to more than double between 1978 and 2000, from about 35 million barrels of oil equivalent per day (MMboepd) to 75 MMboepd, and to increase by a further 70 per cent to 2025. However, by these estimates, the share of oil declines significantly while that of coal increases. Natural gas, both by pipeline and as LNG shipped by tankers, is expected to increase appreciably from the early 1980s until the middle or late 1990s, and then begin to decline. Inter-regional trade in electricity is likely to remain a small part of total energy trade. Uranium and other nuclear fuels might experience pronounced increases in trade but they, too, will not figure largely in inter-regional movements of energy resources. Shipments of nuclear fuels will decrease once breeder reactors are brought into extensive use. Renewable energy resources are not expected to be a substantial factor in inter-regional trade.

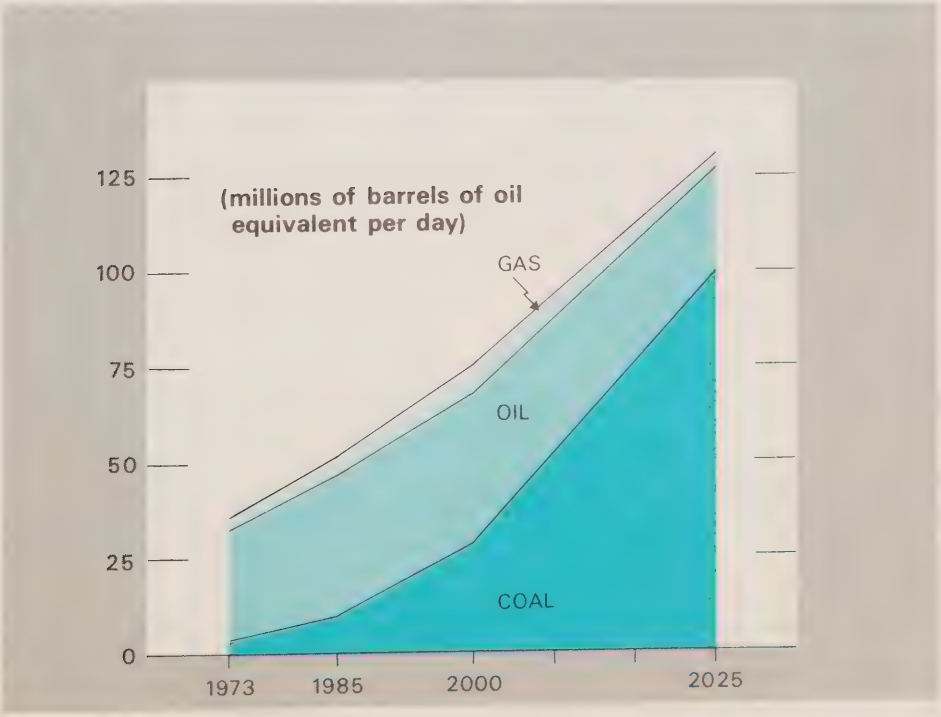


Figure 6. Inter-regional world energy trade.

World trade in oil will be severely constrained by the production limitations noted above. Thus, world trade in oil might increase only by about one-third between now and 2000, but then decline to below current levels by 2025. Oil, which now supplies about 90 per cent of the thermal value of world trade, would be supplying just over 50 per cent by 2000, and only 20 per cent by 2025. Coal would make up most of the remainder.

Around the turn of the century coal might surpass oil as the principal energy resource in world trade, and become by far the dominant traded resource by 2025. Such ascendancy in world trade of coal confronts major difficulties. The sheer logistics of producing and moving such vast quantities of coal (even if shipped in gaseous or liquid form) pose massive problems. The mining and combustion of so much coal could have intolerable environmental effects, most serious of which might be the increase in carbon dioxide in the atmosphere. Moreover, coal supplies, like oil, might not be readily available to support such great volumes of trade. World coal reserves are huge, but production and shipment are difficult. The United States and the Soviet Union have the most readily available coal reserves for export, but their own requirements (particularly those of the United States), by 2000, might severely tax their productive capacities. Further out in time, coal reserves, like oil, will decline.

Taken in total, world trade in energy resources will pose very serious difficulties and require a substantial swing away from oil shipments to coal, in one form or another. As with energy production, there is no reason to expect that these changes in trade, or the changes in energy demands which would support them, will take place easily. A vast amount of advance planning, preparation and action is required in the very short time available.

3. ACHIEVING SATISFACTORY ENERGY BALANCES IN CANADA

Canada and the world

The extremely difficult energy adjustments which confront the world will have serious repercussions in Canada. Quite apart from trade in energy resources, any country so exposed to international events must be substantially affected by economic and social activities abroad, especially during tumultuous times. There are many similarities between the interprovincial and interregional energy outlook for Canada and that for the regions of the world as a whole. Thus, many of the transformations in energy demand and supply, which are necessary on a world scale, will also be necessary in Canada.

There also are some fundamental differences between the energy situation in Canada and for the world. In relation to population, perhaps no country in the world is better served than Canada with the vastness and variety of its energy resources. Yet few countries face greater puzzles and complexities to take advantage of the resources. Because of those difficulties, we are not in a position to pick and choose among a wide range of satisfactory supply possibilities. We will have to exert tremendous efforts to bring together some satisfactory combination of energy supplies, and to transform patterns of demand to match that energy which we demonstrate that we can have.

Canada's energy-related international activities are expected to increase appreciably over the coming 25 years, and continue to increase beyond that. Figure 7 illustrates some of the linkages which are expected to grow in importance as the global interdependence of all countries continues to increase. Those international linkages for Canada can rest upon a growing comparative advantage in the supply and cost of energy; on the sale in Canada and abroad of a wider range of goods and services which embody that energy, and upon the use in Canada and the sale abroad of technologies, management systems and energy-related equipment, designed to meet our energy needs but also adaptable to use elsewhere.

At some time after 1985, the world price of oil no longer will be the main reference price for energy in Canada. The cost of producing our own energy resources will be below the world price of oil. It is in the context of those favourable future energy costs and prices that our energy programs can be based. At present, many factors combine to make Canadian-supplied energy appear to be high cost in comparison with world oil. Those factors include: the large-scale development of remote and difficult

Figure 7. Canada's growing energy links with the world.

resources in Canada, the increase use of electricity, including nuclear power, and substantial efforts to change the ways in which energy is used. In terms of past costs of energy, many of those activities are high-cost. However, as the real price of oil and of other world energy resources increase over the coming 10 to 15 years (possibly not appreciably for a year or two), the Canadian programs to change patterns of demand and use Canadian energy supplies will become competitively priced. A major difficulty, therefore, is that the adjustment processes based on the perception of those higher prices should be well underway now, whereas the tendency quite naturally is to wait until the higher prices exist and then adjust accordingly. That delay could exact very high costs in terms of economic dislocations and social distress.

Transforming energy balances within Canada

To avoid a growing reliance on imported oil, a policy of sustainable self-reliance in energy is recommended for Canada. This calls for major adjustments before the year 2000. If that transformation can be made, the further transitions beyond 2000, although still very great, should fall more readily into place.

Sustainable self-reliance in energy means that our vulnerability to external disruptions in energy supply, or to very great increases in world energy prices, would be negligible. (The economic and social effects of any serious world disruptions would, of course, continue to be felt.) Without such a policy of sustainable self-reliance, Canada's dependency on imported oil might increase until imported oil was providing well over 50 per cent of Canada's oil requirements before the year 2000, and nearly one-quarter of our total primary energy (and an even higher proportion at point of final use). Such a growing dependency on world oil would be taking place at the time when world availability of oil would be declining sharply. For a country with such great energy resources to permit that growing vulnerability to occur is surely irresponsible in terms of its own national interest and in terms of the pressing needs of other countries. A successful national energy program might reduce imported oil to 10 or 15 per cent of our total oil requirements by 2000 -- a negligible part of total energy requirements. The share would continue to decline from then on. Patterns of energy use would have changed to reduce even further any unfavourable impact which might result from an interruption in world oil supplies.

Thus, to support sustainable energy balances, three major adjustments are required:

- reduce appreciably the share of oil in total energy supply, and eliminate dependency on imported oil;
- transform energy uses to conform with new combinations of indigenous energy supplies, and reduce the rate of increase in energy demand as much as possible, consistent with satisfactory economic performance; and
- evaluate, within a Consolidated Energy Supply Program, all potential Canadian supplies so that they can be phased in as appropriate and as economically justified.

A lower rate of growth in demand

The demand for energy has grown in Canada at about 5.3 per cent a year over the past 20 to 25 years. The target is to cut that rate of growth in half from 1978 to 2000, and to bring the growth

rate in energy down to about 1 per cent a year, on average, from 2000 to 2025. These lower rates of growth in energy demand would continue to support satisfactory income performance in Canada, although at lower rates of economic growth, and to support satisfactory, though considerably different, lifestyles for Canadians.

The lower rates of economic growth are the result of lower rates of population growth, an aging of the population, and changes in industrial and economic structure. The lower economic growth rates, here specified, are not the result of deficiencies in energy supply. The assessment is based upon maintaining energy supplies sufficient to support satisfactory economic performance. However, the rates of growth illustrated in Table 1 are considered to be as low as is consistent with satisfactory performance. If full advantage is taken of the economic opportunities which can become available as a result of a successful energy transition, higher growth rates and higher energy consumption could result. In all instances, intensive efforts are required for energy conservation and increased efficiency in its use.

Programs to bring patterns of demand in line with the energy which we can have in the future are outlined in Section 5.

If the energy adjustments are successfully put in place, the difficult structural changes to the economy and to ways of life are expected to be made progressively, but rapidly, over the next 25 to 50 years, without drastic measures of energy allocations, rationing or controls. To achieve so ambitious a target calls for the active support and participation of all Canadians.

The lower growth rates in energy demand can contribute about one-half of the total adjustment which will be needed to bring about new and satisfactory energy balances.

Table 1 summarizes some of the changes in population, gross national product and in energy consistent with the lower energy demands. Within Table 1, three factors in particular contribute to the lower growth rates in energy demand. The factors are:

- a lower rate of increase in population;
- a lower rate of increase in gross national product (even on a per capita basis); and
- an increase in energy efficiency (represented in the table by the decline in the ratio of primary energy to gross national product -- a reduction in the amount of energy used per unit of output).

The principal factors in the lower growth rates in energy demand are shown in Figure 8 as: a "naturally slowing economy" (based mostly on the lower rate of population increase); increased efficiency (as noted above), and "changing society" which implies

TABLE 1

Changes in Population, Gross National Product and Energy Production, 1975, 2000, 2025

	1975	2000	2025	Rates of change 1975-2000	2000-2025	1975-2025	1960-1975
					(per cent/year)		
1. Population (millions)	22.8	30	33	1.2	0.5	0.7	1.6
2. Gross National Product (billions 1975$)	161	375	560	3.4	1.6	2.5	5.0
3. Personal Disposable Income (billions 1975$)	108	250	375	2.3	1.1	1.7	3.2
4. Primary Energy (quads)(1)	8	16	20	2.8	0.9	1.7	5.3
5. Primary Energy/GNP (1975 = 100)	100	86	72	-0.6	-0.7	-0.7	0.4

(1) A "quad" of energy is one "quadrillion" British Thermal Units (10^{15}). The "exajoule" in the metric system is about equal to 0.95 quads.

that lifestyles change in ways which are less energy-using than at present. The lowest line on the chart would represent a situation in which energy supplies are not maintained at a satisfactory level. If that situation begins to develop, increased strains on the economy will come from efforts to increase energy supplies. On the other hand, if rates of increase in demand are too high, greater strains are imposed by efforts to bring demand down to more manageable levels. There is some band of supply-demand conditions for which the stresses and strains are within acceptable balance, and a satisfactory energy situation exists.

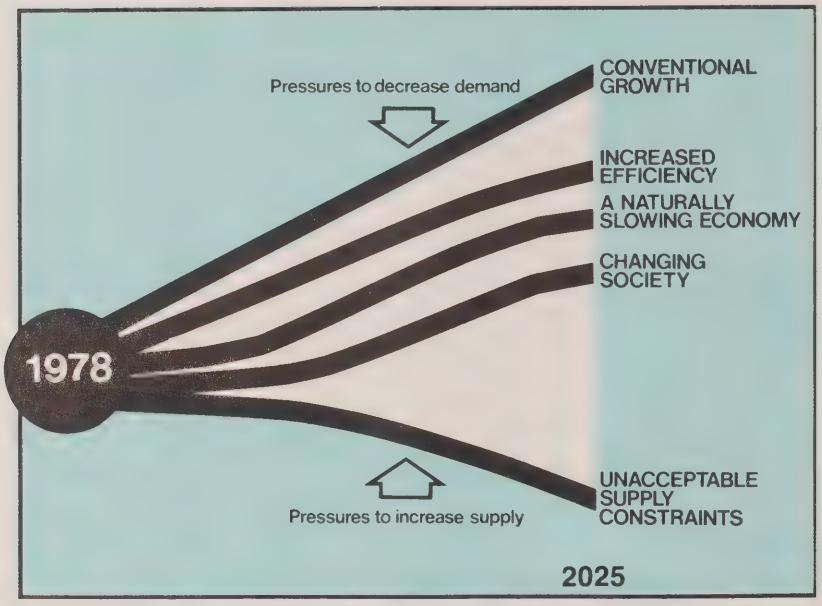


Figure 8. Illustration of changing demand.

The improvements in energy efficiency which were shown in Table 1 call for very substantial conservation and efficiency efforts by householders, industry, within the transportation sector, by the commercial sector and within the energy industries themselves. To achieve declines of the order indicated will represent a major achievement -- greater than anything previously achieved on so great a scale, and maintained over such a long period of time. Moreover, the improvements in energy efficiency will be taking place at a time when the energy needs of the energy industries themselves, to bring on and deliver more remote and difficult resources, are increasing substantially. The drive for greater efficiency by all energy producers and users is, therefore, a key element to a successful energy adjustment. Those improvements also encompass most of the favourable impact of changing lifestyles (although some of that impact also is contained in the lower rates of increase in gross national product). The "lifestyle" changes include major adjustments such as new housing and urban designs which are more energy efficient; changes in transportation systems, possibly with "commuter" or "shopping" carts; electrified railroads; incentives for car pools; enclosed city cores; fewer single-family houses; shorter working weeks; and the substitution of advanced communication systems for some travel. The "lifestyle" changes do not assume any mass exodus

from cities, although some decentralization might occur. Changes are assumed to be voluntary expressions of personal choice, not forced.

Taken altogether, therefore, reductions in the rate of growth in energy demand can make a substantial contribution to lower energy needs. Even so, the amount of energy which is required by the year 2000 is twice the amount which Canadians now use. Some of the contributions of the specific demand adjustments to the achievement of satisfactory energy balances are set out later in this section.

Transformation of energy end-use

Systematic, structural changes in demand will be required to further reduce the use of energy and to ensure that satisfactory balances are struck, over the long-term, between new patterns of energy end-uses and supply. Five programs are recommended to bring about these demand objectives. (See also Section 5.) In the main, these programs represent a functional approach to the end uses of energy (noted within brackets). The five programs are:

- a National Space Heating Program (principally low-temperature heat);
- a Transportation Energy Program (principally mobile energy);
- an Industrial Energy Program (high-temperature process heat and stationary mechanical drive);
- a Consumer Products Energy Program (lighting and appliances); and
- a Community Energy Design Program (all energy systems in combination)

In brief, the programs to achieve structural changes for new energy balances are:

- **National Space Heating Program.** One objective is to reduce by half energy requirements for space heating. Another objective is to achieve new balances between revised heating systems and new sources of energy for that function. These objectives would be accomplished by a combination of many actions to bring about new supply-demand balances. Large-scale insulation and other "retrofit" programs, on which a beginning has been made, are one part of such a program. Energy efficient designs for new households, commercial and industrial buildings and government buildings, are another important component. Byproduct

heat sources and district heating also will be called more into use, as will improved operations and maintenance of heating systems, and the increased use of automatic control devices. Space cooling and water heating and cooling are related matters for investigation. Heat storage and transfer systems and improved efficiency in heating and cooling equipment are important features of these programs. These modifications in space heating would be accompanied by substantial reductions in the use of oil for that purpose, toward the target of virtually moving oil out of space heating. In this way, the National Heating Program represents a comprehensive functional approach to energy use and supply. The program would meet low-temperature heating needs in each locality by a combination of available sources which are not now being fully utilized.

- **Transportation Energy Program.** The two principal objectives are to ensure that the transportation sector does not increase, and preferably declines, as a share of total energy use, and to reduce the use of oil products to about 75 per cent of total energy used in transportation rather than the near 100 per cent which they now are. During the years of cheap and abundant energy, little attention was paid to its efficient use in transportation. Methods are already being implemented or investigated to increase efficiency and to reduce the demand for oil. Substantial institutional and regulatory changes are called for. In the longer term, more extensive changes are possible. These involve, for example, substantial urban redesign for transportation efficiencies, new technologies for public transit systems. Increased efforts will have to be made to use other liquid fuels and electricity for transportation. The use of small, electric or liquid fuel (not necessarily gasoline) "commuter" and "shopping" carts, greatly improved freight handling systems, and greater rationalization of intermodal transport systems are other ways of achieving lower energy use in transportation.

- Industrial Energy Program. Three features of a national industrial (and, as applicable, commercial) energy program merit special attention. These are:

  - exploit all opportunities to increase substantially the operational efficiency with which energy is used by industry and commercial establishments in existing plants, thereby extending existing energy conservation efforts;

  - ensure that all practical use is made of byproduct or "waste" energy available in industry but which is not now used by industry or sold; and

  - introduce as rapidly as possible energy efficient capital equipment and new processes of production.

- **Consumer Products Energy Program.** This program seeks to improve energy efficiency in the production, use and disposal of consumer products. The conservation objective for consumer products is to improve significantly energy efficiency in consumer products, in packaging and in their disposal and reuse. A start has been made in some aspects of these programs. Increased activities call for energy-efficiency labelling and increased energy efficiency in appliances, space conditioning and lighting equipment. Particular attention should be paid to these factors in rental accommodation. Increasing the durability of appliances, their recycling or scrappage value, and the ease of their repair and maintenance are important factors. Public awareness of the benefits to be derived from energy efficiency is an important part of this program.

- **Community Energy Design Program.** This program would treat the community as a single energy "enterprise" to achieve efficiency and structural change in urban centres, in remote and frontier communities, and in inter-urban transportation. The objective is to establish, through design, re-design and structural change, further increases in the energy efficiency of new and existing communities beyond those achieved by the specific programs for space heating, industry, transportation and consumer products.

Consolidated Energy Supply Program

The doubling of energy demand by the year 2000 (Table 1) and the further 25 per cent increase to 2025 call for substantial increases in the physical quantities of energy which must be forthcoming from Canadian resources. In the past, any shortfall in Canadian supplies could be met simply by importing relatively inexpensive and abundant oil or coal. That "fall-back" can no longer be counted on. Reliance on imported resources is, within this energy program, to be reduced, not increased. The additional supplies are to come from Canadian resources.

Existing policies are demonstrating considerable success in tapping new supplies of oil, natural gas, uranium and hydro power. The requirements set out below call for substantially more energy from those sources and from a variety of others. Progress will continually have to be judged in relation to the long-term targets, in a dynamic context which allows for modification of the programs and/or targets.

Although a number of supply combinations are possible, the actual degrees of choice appear to be very small indeed. The task is not to pick one or two winners among the supply possibilities and go after them. The task will involve pushing very hard on all indigenous supply possibilities, selecting perhaps a little more

of one and a little less of another, within a Consolidated Energy Supply Program. The challenge of the Consolidated Energy Supply Program is to achieve the most effective blending, at each point in time, of the available energy supplies in all parts of Canada.

A pattern of energy supply possibilities is presented in Table 2. A number of features of Table 2 merit special attention in terms of the Consolidated Energy Supply Program.

TABLE 2

Changing Patterns of Energy Supply

	1975	2000	2025
Oil ('000 bbls/day)	1 780	2 400	2 500
Natural gas (billion cubic feet/year)	2 500	3 200	3 600
Coal (million tons)	30	120	200
Renewables (excluding conventional hydro) ('000 bbls/day oil equiv.)	-	400	1 000
Electricity (GWe of capacity)	60	210	275
Total (quads)	8	16	20

Oil production is increased by about 50 per cent by the year 2000, and maintained at that level (or higher) to 2025. This is accomplished in spite of an anticipated decline in production in conventional oil fields, and the absence of any pronounced success to date in discovering oil in the frontier regions. For purposes of this assessment, oil production by 2000 and from then to 2025 is assumed to come mainly from the oil sands and heavy oil deposits of western Canada (with additional supplies from the conventional areas or frontiers as these become available). To achieve the requisite oil production by 2000 would require possibly 10 surface-mining oil sand operations, 2 in situ operations and 2 or 3 full-scale heavy oil operations with processing facilities.

Such a program requires commitments of financing, corporate organization, manpower, equipment and materials far greater than any actually planned for within that 20-year time. The program would, in effect, require the construction of one plant about every 18 months from now until the year 2000, compared with a plant about every 5 or 6 years at present. Provincial agreement would be required for the entire program, and the environmental and other impacts would need to be thoroughly assessed, not just for the next oil sand or heavy oils plant, but for a dozen plants. It is apparent that concerted organizational and management procedures of an entirely different kind are called for to bring progressively on stream such vast undertakings.

Even if oil production can be increased to the levels indicated in Table 2, the share of oil in total Canadian energy use is substantially reduced.

Natural gas production is increased by about 30 per cent between 1975 and 2000, and increased further by 2025. Of the 1975 production, more than 40 per cent was exported on long-term contracts. The export contracts expire before 2000 and no allowance is made in these estimates for exports at that time or thereafter.

The increase in natural gas supplies is regarded as of crucial importance to Canada's energy balance, and is one of the high priority Recommended Programs. The increase in production must also offset declines in existing and in some of the future wells. The additional production is expected to come in a series of stages from conventional formations in western Canada, new formations in western Canada, Mackenzie Delta-Beaufort discoveries, East Arctic, and possibly offshore along the east coast. These might be supplemented by imported LNG, by SNG from coal, or other sources of methane or methanol. A new "wedge" of natural gas would be made available, especially in the energy-deficit regions of central and eastern Canada, based on a 30-year assured gas supply. However, in total, the increase in production simply maintains the share of natural gas in total energy supply.

The very substantial increase in coal production which results in a 4-fold increase by 2000 supports much more thermal generation of electricity, as well as other existing and new uses of coal, for example, for steam generation and hydrogen for the oil sands and heavy oils, greater industrial uses of coal, some production of synthetic natural gas (SNG) and liquid fuels, and the use of coal in fluidized bed combustion. The requisite transportation facilities, land-use and environmental standards and protection facilities to support the very much larger use of coal will themselves be massive undertakings.

The penetration of renewable resources to the extent shown would be a noteworthy accomplishment since most of the renewables lack any significant organizational, financial or market base at the present time. To establish so large a market for the renewables, individually and collectively, in so short a time presents Canadians with a major challenge, but one which has a high priority. By the year 2000, renewables would be contributing as much as imported oil at that time, or more than four times the energy currently supplied by nuclear power in Canada -- a prodigious undertaking in 20 years.

As early as possible, the economic feasibility of the various renewable resources should be established, as well as the institutional, regulatory, management and marketing changes which would be required for the extensive deployment of renewable resources, byproduct energy, urban wastes, peat, hydrogen, cogeneration, fluidized beds and district heating systems. A variety of pilot and demonstration projects for renewable and other energy resources should be established across Canada, with special attention to the energy-deficient regions of central and eastern Canada.

The nearly four-fold increase in electricity generation by the year 2000, and the further increase to 2025, as shown in Table 2, is a crucial part of the additions to energy supply. As illustrated later in Figure 11, the generating capacity, by 2000, is based almost equally on hydro power, coal and nuclear, with cogeneration and renewable resources making a smaller contribution. At present, hydro power accounts for over 60 per cent of generating capacity, but the additional available hydro sites will become very few by the turn of the century. The increase in coal-thermal generation of electricity is substantial, but it will confront increasing competition from other uses of coal and from the anticipated competitive advantages of nuclear power. The very large expansion of the use of coal is further limited by potential environmental hazards and land-use considerations. The environmental hazards of the much higher carbon dioxide content of the atmosphere resulting from substantial increases in coal combustion might be especially serious -- a problem for considerable current effort.

Nuclear power for the generation of electricity increases most rapidly, starting as it does from its small present base. This growth in nuclear power rests upon the growing economic advantages, the ample fuel supply (including thorium) and the convenience which nuclear power will have. The use of nuclear power is also driven by the almost insuperable difficulties of finding satisfactory alternatives in sufficient quantities. Nuclear power is the energy which we can have while other resources are being developed and while changes in patterns of energy use are

being made. Moreover, Canada's nuclear capability is based almost entirely on Canadian sources of fuel supply, equipment manufacture and technical expertise. It is a truly indigenous resource, particularly appropriate for use in the energy-deficit regions of central and eastern Canada.

However, the expansion of nuclear power presupposes that perceptions of risk, safety, health and land-use are successfully accommodated, and that sustainable programs of nuclear waste management are satisfactorily implemented within the next few years.(1) The expansion of nuclear generating power on the scale here envisaged also would benefit from, and possibly require that, the thorium cycle, or some variant of a breeder cycle be brought into use, possibly by the turn of the century. There would also seem to be an advantage in trying to use the organic-cooled reactor, especially where high temperature steam is required. Nuclear reactors could also be an important additional source of heat, not only in the form of waste heat, but also by nuclear plants dedicated to the co-generation of heat and electricity. The use of waste heat from nuclear reactors, for example, would do much to improve the overall efficiency and economy of nuclear power, and would reduce a potential problem of waste heat disposal.

It is important to realize that of all Canada's resources, the nuclear power system is the one which offers the most ready scope for expansion to meet Canada's growing energy needs, at least over the next 30 years. No other resource or combination of resources, at present, seem capable of expansion in amounts adequate to meet the energy required for satisfactory economic performance and for maintenance of social well-being.

In this assessment, all other energy resources, including the renewables and byproduct sources of energy, are being increased at a pace which pushes their supply capabilities to what seem to be the practical limits. Reductions in the growth of demand also have been taken in account as far as seem possible if the preferred lifestyles of Canadians are to be sustained. By themselves, those adjustments are insufficient. Even some further demand reductions and increases in other energy supplies would leave a gap to be filled by nuclear power. The same situation exists to

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(1) A recent, independent, study commissioned by Energy, Mines and Resources Canada has examined waste management programs. See: "The Management of Canada's Nuclear Wastes", A.M. Aikin, J.M. Harrison and F.K. Hare (Chairman); Energy, Mines and Resources Canada; August 31, 1977; Report EP 77-6.

an even more serious extent on a world scale. Overcoming the hazards of nuclear power, or the perceptions of hazards, ranks as a very high priority matter for Canada and for the world.

If the public is convinced that the potential hazards of nuclear power are too great, its expansion will be seriously curtailed. In that circumstance, Canada, in keeping with most other countries, would face a seriously constrained energy future -- one that could cause substantial changes in lifestyles and, quite probably, disruptive processes of adjustment.

Nuclear power, in effect, also offers the energy "fallback" capability which was previously provided by imported oil. Energy from nuclear generation can be readily increased further if other sources of supply fall behind target. The difficulty will come from trying to accelerate the substitution of electricity for other forms of energy in the end-uses. Nuclear power thus adds a measure of flexibility and resiliency to the energy system provided that transformations are made toward greater use of electricity.

New energy balances

The adjustments which will be made to energy demand and to energy supply are essential to the achievement of satisfactory energy balances, but they are not, of themselves, sufficient. The transformations in demand and supply will be great, but they must match. They must come together as a new energy system in which supplies are made available, as far as possible, to meet preferred demands for energy, and the uses of energy are adapted to the supplies which can be made available. Not only are total supplies lower than a continuation of past demand trends would require, but there are also substantial changes in the composition of supplies. These changes require the substitution of different energy resources for ones now used. The principal substitution is aimed at driving out imported oil in the heavily reliant regions of central and eastern Canada.

Two features of the transformations are used to illustrate the nature of the required substitutions:

- the proportionate change in the composition of demand among principal uses of energy; and
- the proportionate change in energy supplies.

Figure 9 shows that patterns of energy demand change toward greater relative emphasis on industrial use and a smaller share of energy for residential use. That change occurs primarily because the lower rates of population growth, the general aging of the

population, smaller family (or "household") size which result in smaller average household space, and the use of more multiple-unit dwellings (condominiums and apartments). Opportunities for greater energy conservation and increased efficiency can also have a greater, immediate impact on residential energy use.

The share of the commercial sector does not change appreciably but that represents a significant application of greater efficiency in energy use and structural changes to restrain energy growth. Over the past 15 years, the commercial sector has been the most rapidly growing energy user. The constraint of its further, relative growth is, therefore, noteworthy.

Energy requirements for transportation also have been growing rapidly. However, substantial increases in energy efficiency, particularly in the mileage performance of automobiles, the size of automobiles and lower speed limits, will have an immediate effect on energy used in transportation. In the longer run, even greater changes in transportation modes and efficiency are needed, particularly to hold down the expansion of the use of oil products

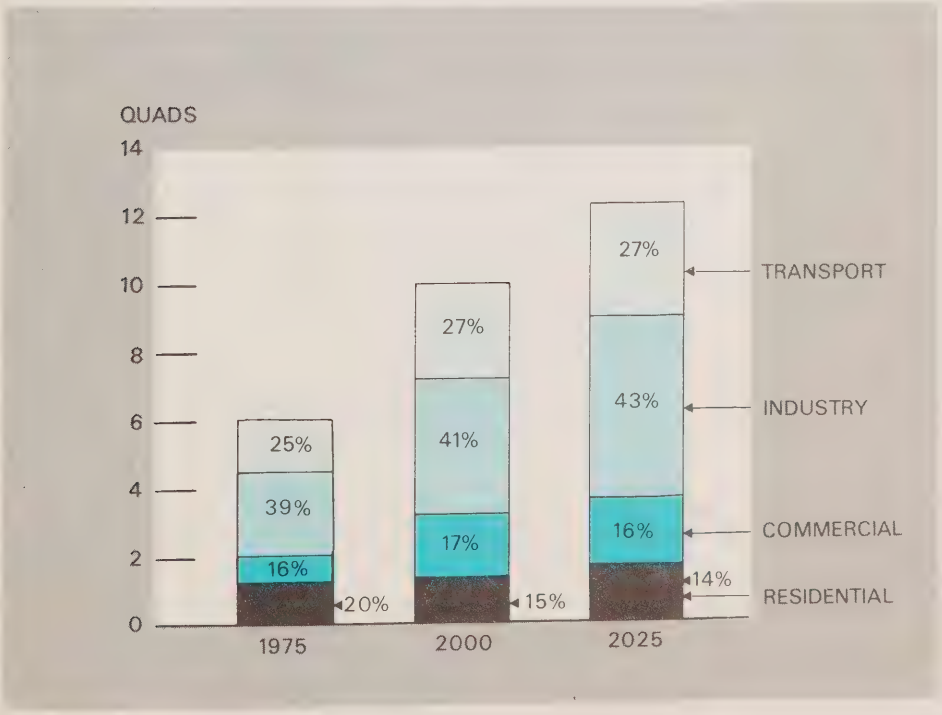


Figure 9. Energy demand by principal uses.

in transportation. Thus, the moderate rate of increase in the share of transportation in total energy use results from very substantial efforts to prevent that share from increasing much more. The ultimate target is more ambitious -- to see no increase or even some decline in the share of transportation. However, that is an extremely difficult target, especially by the year 2000.

Even with the constrained growth in the use of energy by all of the principal sectors, a disturbing trend is developing. The industrial and transportation sectors, which are increasing in relative terms, are particularly heavy users of oil. Together, in 1975, those two sectors accounted for about 70 per cent of all of the oil used and, especially within transportation, the substitution of other fuels for oil products will be extremely difficult. Substitutions within the smaller oil users -- the household and commercial sectors -- are easier to make, but will have less overall impact on total oil requirements. Thus, the changing patterns of demand do not, in the first instance, support the objective of substituting other energy resources for oil. Efforts to achieve those substitutions will have to be particularly great and deliberately planned from this time forward.

On the supply side, the share of oil declines even with the very substantial efforts to bring on supplies from the oil sands and heavy oil deposits. The changing supply shares are shown in Figure 10. In Figure 11, changes from existing patterns of use are noted.

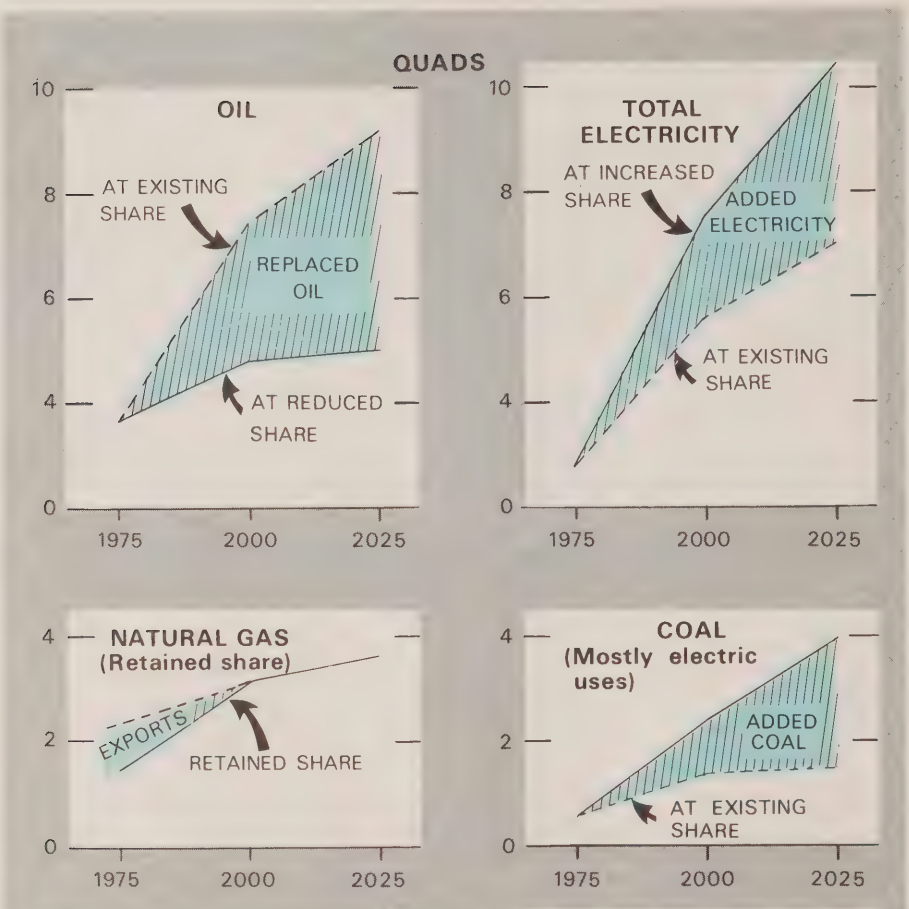
The major changes in energy supplies are represented by the declining share of oil and the increasing share of electricity. The contribution by the renewable resources to electricity generation, to heat use, and possibly to liquid fuels, is significant. The magnitude of the contribution of the renewables is limited, especially over the next 25 years, by the time taken for those resources to establish a place in the market and to develop the organizational, financial, managerial and institutional capabilities to supply a large market. The renewable resources, before 2025, might supply a larger part of total energy requirements although there is ultimately a finite limit to their total availability.

An important feature of the energy supply combinations is that, by 2000, they achieve a relationship which is essentially sustainable beyond the year 2025. The changes in shares after 2000 are essentially a continuation of patterns which have been established by that time. The oil and natural gas reserves, for example, are expected to be able to sustain those supplies; coal production, electricity production and the use of renewable resources and of byproduct forms of energy can be further increased.

The problem referred to above remains -- the changing patterns of demand favour greater use of oil, whereas changing resource availability and the principal requirement of the energy transformation require a substantial reduction in the share of oil. (It is cut almost in half between 1975 and 2025.) Most of the use of oil can be progressively removed from space heating in residential, commercial, and other buildings. Many energy sources can supply the low-temperature heat which space heating requires. In terms of the mix of products from an oil refinery, that reduction somewhat complements the reduced demand for gasoline which results from greater car efficiency and from other changes in the transportation sector.

The major substitution of other products for oil and the further reduction in the use of oil must eventually be made in the transportation and industrial sectors -- i.e., in "mobile" energy uses, and for stationary, mechanical drive and high temperature process heat.

A number of programs are recommended in Section 5 to bring about the necessary reductions in energy use and substitutions among supplies in order to achieve new, satisfactory energy balances.



CHANGING MARKET SHARES * (per cent)

	1975	2000	2025
OIL	46	30	25
GAS	19	20	18
TOTAL ELECTRICITY	35	47	52
COAL	7	19	20
RENEWABLES & OTHER	—	5	10

* SHARES DO NOT ADD TO 100 PER CENT BECAUSE MOST OF THE COAL AND ONE-HALF OF THE RENEWABLES ARE DUPLICATED IN TOTAL ELECTRICITY

Figure 10. Oil replacement through substitution.

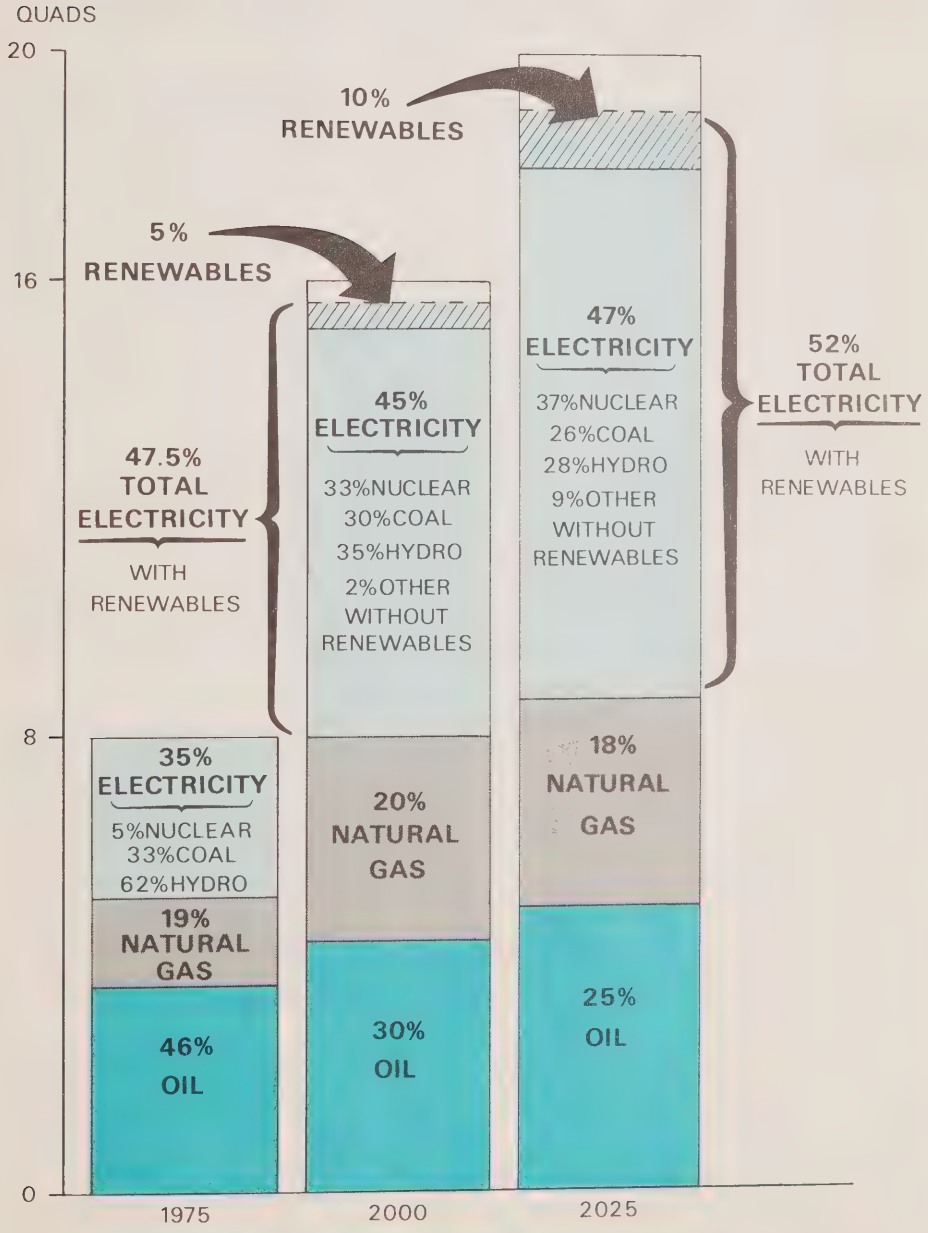


Figure 11. Changing patterns of energy supply.

4. THE PROCESS OF ADJUSTMENT

The achievement of satisfactory energy balances involves far more than identifying ways to bring patterns of supply and use into balance. A great number of complex factors have to come together in appropriate ways if the requisite transformations are to take place. For example, energy prices must change in ways supportive of the new balances. Vast outlays of investment capital must be made for the appropriate projects. The financing must come forward at the appropriate times, usually 10 to 20 years in advance of the need for the new sources of energy or the substantially changed pattern of use. Management systems and supporting fiscal systems, institutions and regulations need to be put in place which will facilitate the major adjustments.

Over the past 30 years, massive energy changes have taken place fairly smoothly and in ways supportive of a dynamic, rapidly growing economy. Those years witnessed the growing dominance of oil and natural gas in the energy systems, and the additional penetration of electricity. Wood and coal as energy sources declined rapidly. A major difference between the energy transformations of the past 30 years and those of the next is that the past changes were toward preferred energy sources, whereas the future changes, at least for many years, will be away from preferred energy forms. Oil, natural gas and electricity, in the past, were abundant, low-cost, clean and very convenient forms of energy, ideally suited to the changes in industrial activity and lifestyles which grew up in large part because of that ready availability. High-cost, scarce and less convenient or efficient forms of energy will rapidly become an increasing part of the future for Canadians and for people in most other countries. The changes will be strongly resisted, particularly since the essential, unavoidable changes might not be evident for several years. For example, complaints about the present high-cost of energy are misplaced when viewed against future prospects. The absence of increases in the real price of world oil also is a "false" signal in terms of future prospects.

The many adjustment factors, therefore, have to be brought together in ways which induce the necessary changes progressively through time. As the energy transformations are being made, new economic and social opportunities will arise. The activities require some shared perceptions of the urgent need, the objectives and the direction of the necessary actions.

Programs to deal with the adjustment factors, therefore, seek to ensure that those factors fully support the necessary energy transformations, that they do not constitute avoidable constraints

to adjustment, and that they are used to exploit whatever opportunities arise from the changing energy situation.

Gateways to feasibility

Any project or program which is part of the energy transformation can be assessed in respect of how well it meets five basic conditions:

- resource availability;
- technological feasibility;
- economic feasibility;
- jurisdictional, institutional, regulatory, managerial and administrative capability; and
- social acceptability.

A project or a program can fail, or be seriously delayed, if it cannot pass through any one of those "gateways of feasibility". At some time before its implementation and deployment, the program or project must pass through all five gates. An objective of the process of adjustment is to ensure that the delays are minimized by removing, as far in advance as possible, and as comprehensively as possible potential constraints in all five categories.

Meeting the adjustment challenges

Chapters 8 to 12 of the report deal with the following adjustment factors:

- energy prices and pricing;
- financing, ownership and control;
- technology, research and development;
- environmental, health, land-use and other social considerations;
- institutions, regulations, administration and management provisions;
- manpower, equipment, materials and infrastructure; and
- information, communications and participation programs.

The successful implementation of these adjustment factors is an essential component of a National Energy Program. Each of the factors require complex processes of change from current procedures. Each can be assessed and changed individually, involving participants in the energy industries, other industries, labour

organizations, financial institutions, governments, public utilities, special and local interest groups. Beyond that, however, it is essential that energy programs be assessed in terms of the combination and harmonization of adjustment factors necessary for success.

Energy prices

Energy prices are the essential key to the adjustment process. We will not be able to have low energy prices (by past or present standards) and an adequate supply of energy at the same time. Price relationships will largely determine whether satisfactory energy balances will be achieved. Price changes should support four fundamental objectives:

- decrease and modify energy demand;
- increase energy supply;
- induce the substitution of other resources for oil; and
- support enhanced economic and social well-being for Canadians.

Two indicative pricing targets have been noted. In brief, these require that:

- energy prices be the equivalent of world oil prices, at least until costs of energy production are below world oil price equivalence; and
- price differentials should encourage necessary interfuel substitutions.

Although the real price of oil is expected to double before 2000, the possible absence of significant increases in the next few years will delay reductions in demand and the substitution of other energy resources for oil. However, before 2000, most energy resources in Canada are likely to have costs of production below the equivalent of world oil prices and, therefore, be competitive as sources of supply.

This is especially significant for electricity which will increasingly become the dominant Canadian energy source. Under these circumstances, the price of the kilowatt hour is likely to become the reference price for energy in Canada. Ultimately, the price of the kilowatt hour will itself probably be based upon the cost of nuclear generation of electricity. This does not mean that all electricity will come from nuclear generation, but that other sources of electricity will have to be competitive with the cost of nuclear power.

It is important that price differentials develop among energy resources to provide incentives to substitute new patterns of supply and use for the existing ones, particularly in ways to moderate substantially further increases in the use of oil. Interfuel substitutions are much more difficult to achieve if all forms of energy are priced at the equivalence of the highest priced fuel, thus inducing windfall gains (or "economic rent") for the lower cost supplies. Where windfall gains do occur as a result of the pricing of a resource above long-term costs of production (and a "normal" profit), they should, however allocated, help to support the next phase of the energy transformation. These are among the most difficult relationships to work out in a satisfactory way.

Each of the energy resources has difficult price adjustments to make. These will not automatically be consistent with the objectives of energy self-reliance and interfuel substitutions. One important consideration in this regard is the extent to which energy prices, the distribution of revenues, and the adequacy of industry cash flows will support the financial investment required to bring on the additional supplies and make them competitive in the marketplace.

The clarification of price objectives and the achievement of consistency among the objectives to serve long-term energy adjustments is an extremely difficult and hazardous undertaking. One example of the difficulty is that clear signals of further substantial increases in the real prices of energy might not be forthcoming for some years, but adjustments to meet the impact of the higher prices require an immediate beginning. Another difficult problem is that increases in energy prices quite naturally are met with considerable resentment by people adversely affected by them. The resentment is especially pronounced when the price increases seem to be controlled or manipulated by one or another small group of suppliers, users or government officials. In addition, a tendency to price all energy resources up to equivalence with the highest price source blunts the incentive to make necessary substitutions. For those and many other reasons, the objectives of pricing practices should be made as clear and as consistent as possible.

A number of volunteer task forces or other groups can assess the complex energy price considerations, with a view to ensuring that energy prices contribute to the achievement of appropriate energy balances through the next stages of the transformation. To a greater extent than in the past, prices will be "administered" -- i.e., under the influence or control of forces other than the free play of the market. The bringing to bear of such forces now seems to be inevitable, even essential, but the purposes which they are to serve are not always clear.

Financing, ownership and control

Future financial requirements of the energy sector and of energy-related activities will remain at relatively high levels beyond 1990 and, indeed, beyond the year 2000, with all of the accompanying employment and other support activity which such investment implies. The Energy Strategy Report of 1976 estimated that investment in energy projects might amount to $180 billion, or more, (1975$) from 1975 to 1990. The Energy Futures report confirms the need for such levels of capital spending, and indicates that even greater amounts might be needed over that period of time. Further increases in capital spending will be required beyond 1990. Expressed in relation to gross national product, energy-related investments might average close to 6 per cent of gross national product from 1978 to 2000, and possibly 4.5 per cent from 2000 to 2025, in comparison with about 3.4 per cent from 1950 to 1975.

The energy requirements for sustainable self-reliance, as set down in this report, will call for increased investment in conventional energy supplies -- electricity, oil and natural gas production and pipelines, and coal mines. However, accelerated programs are also needed for the more recently introduced supplies and those nearing commercial use -- oil sands, heavy oils, new nuclear technologies, biomass, tidal and solar power, byproduct energy sources, co-generation and district heating. The National Energy Program here recommended also would require substantial capital outlays for energy conservation and efficiency and structural changes to demand -- new housing designs, industrial equipment, re-designed communities and transportation systems. It would also require extensive environmental outlays and a substantial build-up of energy support industries, for pilot and demonstration projects, for construction systems, rail and ship terminals, and new or enlarged communities. Beyond those capital outlays are others related to new industrial opportunities arising from the use of energy. In total, the scope of investment activities is very much enlarged in support of achieving satisfactory energy balances. More economic and social activities are drawn into the ambit of the energy transformations.

It is apparent that such a high level of investment activity can occur only within a healthy, dynamic economy, and that such levels of investment in energy-related projects will do much to sustain satisfactory economic performance in Canada far into the future. These dynamic economic interactions will also increase the opportunities to introduce new energy-saving machinery and structures.

In substantial degree, the financing for the much expanded capital investment will be raised in traditional ways in the energy industries, the financial institutions, the provincial utilities, or from major customers. However, many new and enlarged financial requirements will call for new sourcing of funds, possibly through joint ventures, consortia, and revolving investment funds. Undoubtedly, government participation in financing will increase, directly or indirectly. In total, adequate funds might be available, in Canada and abroad, but uncertainties, greater risks and the presence of more outside factors beyond the specific project, will create additional difficulties. Comprehensive assessments are needed of the total financial requirements of the much expanded energy-related investments, their possible timing, the sourcing of funds and the financial incentives and innovations needed to ensure success.

Closely related to investment and financing are questions of ownership and control. As with financing, the nature of ownership and control also will change appreciably. The likelihood is that ownership and control will be less closely tied to financing from traditional sources than in the past. Greater government ownership and control (federal, provincial and local), and more dispersed public intervention and financial participation also will affect the nature of ownership and control. A possible increase in debt financing rather than equity financing will alter the ownership and control structure.

Other factors of adjustment

A number of other, crucial factors of adjustment were listed at the beginning of the section. Each of those in turn requires careful assessment and modification in order to serve the energy transformation process. Moreover, a comprehensive approach is needed, encompassing all of the strategic factors together. Such a process would be carried out in relation to specific energy programs, the implementation of which would require that all constraints and opportunities associated with that program be systematically dealt with.

One important concern, for example, relates to the institutions and regulations which so largely determine what can and will be done. The major energy-related institutions require careful review, not so much to see whether they are effectively fulfilling their present mandate, but to see what revisions would be required to enable them to meet the many new tasks. Are the provincial electricity utilities, for example, the appropriate institutions to carry out programs of electricity conservation, the introduction of solar power, and co-generation of heat and electricity in

a large industrial plant? Are the organization and functions of the National Energy Board or the Atomic Energy Control Board appropriate to the investigation and supervision of projects and energy systems which have major, long-term national impacts or which, on the other hand, are mostly local or regional?

A similar review is in order for institutions charged with environmental protection, health and land-use. Large-scale, comprehensive programs to meet long-term energy needs impose a new kind of responsibility as well as a new magnitude of responsibility on such institutions. Also, comparative environmental evaluations are required so that the possible constraint on one program or resource can be compared with others and as equitable an impact as possible result from environmental, health, land use and ownership, and other social concerns.

Somewhat similar considerations arise concerning Research and Development (R&D). In terms of successful long-term energy adjustments, three principal conditions must be met:

- R&D priorities must be consistent (at the applied levels) with the priority requirements of the requisite long-term energy adjustments;
- the R&D concept must be very greatly broadened, to include demonstration projects and successful deployment of technological innovations into significant use; the broader concept, therefore, is RDD&D; and
- the application of technological innovation must be broadened to deal with constraints and opportunities wherever they appear within the energy-related activities. At present, for example, the perception which many people have of the hazards of nuclear energy is a constraint on its application. Those perceptions are a justified matter for thorough investigation so that either the perceptions can be corrected or the hazards removed or controlled. As with environmental concerns, comparative evaluations are in order as, for example, between the possible nuclear hazards and those associated with the possible impact on the environment of large quantities of carbon dioxide from the combustion of hydrocarbon fuels such as coal and oil, or from extensive use of solar or biomass energy.

The strategic adjustment factors, therefore, need to be considered separately and together in relation to every significant energy program. The combined impacts of all of the programs on financing, pricing, manpower, the environment, the relevant institutions, R&D, and so on, also need to be taken into account if concerted programs are to be carried out to meet long-term energy needs.

5. RECOMMENDATIONS

The situation and the necessity

This assessment concludes that the world energy situation could well enter an extremely critical phase within the next 10 or 15 years -- so critical that the well-being of people in many countries might be seriously damaged and world order itself threatened. The deteriorating world energy situation will show up in the form of much higher prices and as serious disruptions to energy supply. The difficulties will be evident first in the world supply of oil. Even if this "Futures" assessment has overestimated the magnitude or speed of the deterioration, the basic direction of movement remains. At best, we would have a few more years to make the major transformations that are required.

The chapters of the report outline how new energy balances might be achieved in Canada over the next 25 years. They deal with the need for substantial institutional changes and for a clear, systematic approach to other factors of adjustment -- prices, financing, technological innovation, environmental concerns, land-use, etc. The need for a dynamic, comprehensive approach to Canada's long-term energy future is dealt with in the report as a National Energy Program.

The National Energy Program requires that the public and the principal decision-makers, in general, share perceptions of the long-term future and of the need to take initiatives now to deal with it. Those initiatives would extend beyond the many current programs and activities which are being put in place to deal with the immediate situation and the mid-term future (the coming 10 years).

A number of the components of the National Energy Program establish the framework within which the recommendations are made. The long-term indicative targets which underlie the program were presented earlier in this Summary (see page 5). These relate to five main policy elements which are shown in Figure 12, together with a number of recommended programs for each policy element. Each recommended program, in turn, has its own targets and recommended actions.

National Energy Program

The various adjustments to the energy support system for our economy and society can be most effective if they are approached comprehensively within a series of programs which, taken together,

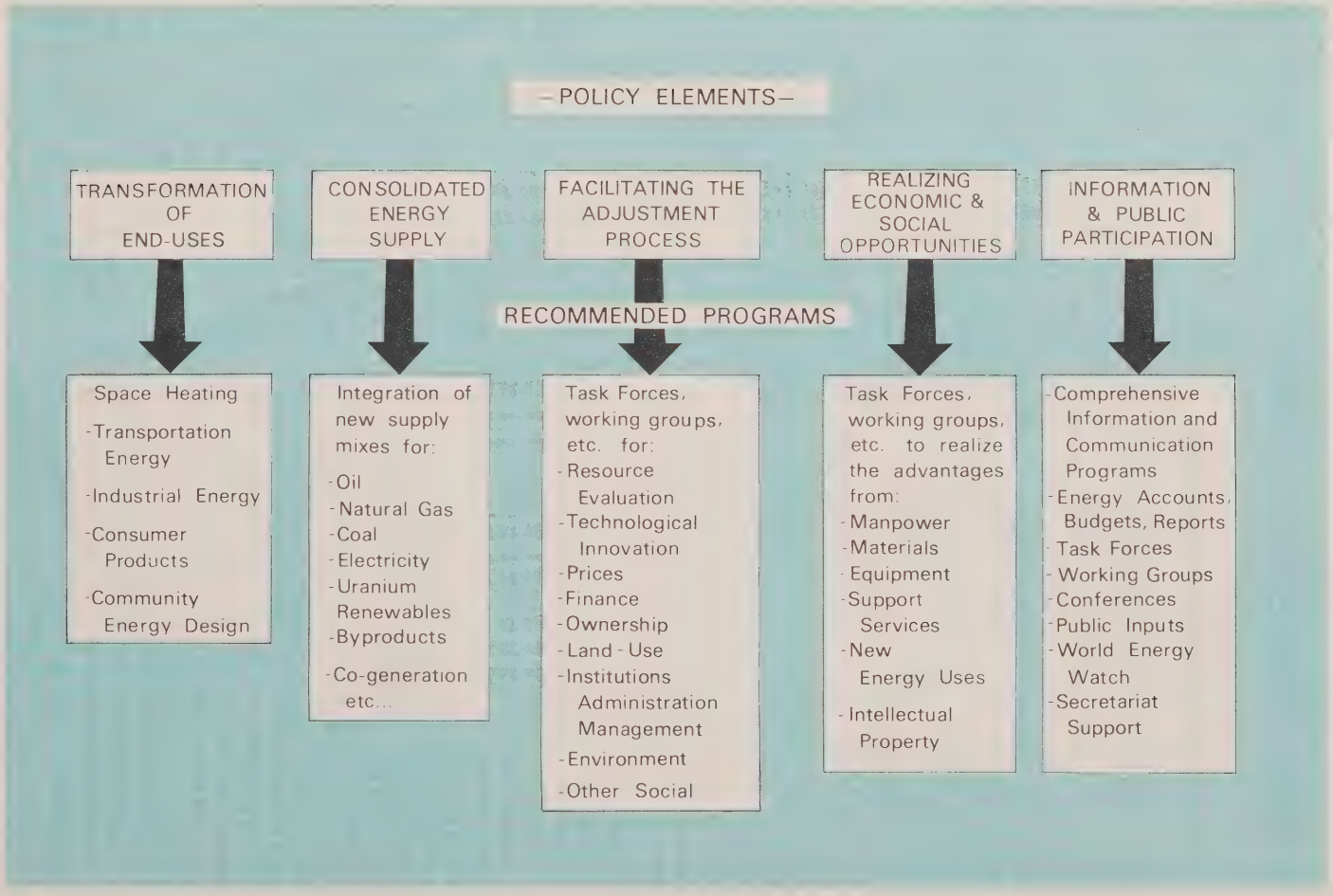


Figure 12. Principal Recommended Programs.

become a National Energy Program. Those programs, individually and collectively, require the dedicated participation of people all across Canada -- as users, as suppliers, as financiers, managers, labour union leaders, scientists, city planners or government administrators or political leaders. So pervasive are those impacts that virtually every Canadian has something to contribute to the success or failure of our energy futures.

A number of specific programs are recommended to ensure that the participation can be made with a clear understanding of its purpose, the indicative targets of what is to be achieved, some idea of the timing or programming of activities and some means to evaluate progress and revise the targets or the programs as subsequent events require. Discussion and debate are very much in order. Hence, for each program, and for many of the components of the program, volunteer task forces and other groups would consult and advise, and members of those groups would act in their own areas of interest in all parts of Canada. Coordination of effort would be an essential feature of the National Energy Program as a whole.

Because of the all-pervasive nature of the required participation, no recommendations are made concerning the jurisdictional responsibilities or the institutional organization. It is apparent that the federal and provincial governments and the energy-related industries have major initiating roles, and that the federal government in particular will be called upon for much of the coordinating activity and the communications processes.

The Recommended Programs have five main thrusts related to the overall objective of achieving satisfactory energy balances for sustainable self-reliance in energy from 1978 to 2025. Those new energy balances would support satisfactory economic performance and enhance individual and social well-being. The programs are consistent with the principal indicative targets (Section 1).

Designated program areas and recommended actions

The five main thrusts of the Recommended Programs are:

(1) Transformation of end-uses (five sets of recommended actions).

(2) A Consolidated Energy Supply Program (seven sets of recommended actions).

(3) Programs to deal with Energy Constraints and Opportunities (eight sets of recommended actions).

(4) Programs to deal with Economic and Social Opportunities (four recommended actions).

(5) An Energy Information and Participation Program (four recommended actions).

Not all of the programs can be fully undertaken at once, although current initiatives in all parts of the country will relate to one or more of the programs. Each program has its own targets and recommended actions. These are set out in some detail in the Energy Futures report.

Three programs are assigned particularly high priority because:

- they have special importance in their own right in the achievement of new, satisfactory energy balances;
- they represent new, broad approaches to the energy transformations which go beyond specific energy conservation programs or specific supply projects; and
- they provide appropriate links to the other programs and to widespread public participation.

The three programs are:

- a National Space Heating Program (out of (1) above);
- an Increased Natural Gas Supply Program (out of (2) above); and
- an Energy Information and Participation Program (out of (5) above).

Details of the 28 recommended programs and actions are outlined in Chapter 13 of the Futures report. Three recommended programs and their related actions are used here by way of illustration. These are: the Information and Participation Program, the National Heating Program and the natural gas segment of the Consolidated Supply Program. Initiatives already in place, supportive of the Energy Strategy to 1990, provide an effective launching pad for the comprehensive, long-term efforts which are now required for those programs and for many of the others.

Although the recommended programs and actions can proceed individually, and in one locality or another, their total effectiveness will only be realized if the implementation of each is evaluated within the framework of the total perceived requirements. The totality of Canada's long-term energy adjustment in support of new economic, individual and social opportunities is the issue. The individual programs and current initiatives can be assessed against long-term indicative targets, progress toward those targets, or toward revised courses of action in the light of changing circumstances. In this way, current energy initiatives continually rank high on the nation's agenda.

Energy Information and Participation Program

Program objectives:

- ensure that Canada's long-term energy future is given high priority on the agenda of the nation, and that decisions in all parts of the country are based on the fullest possible information;
- ensure that the public is aware of the national threat posed by the evolving energy situation in Canada and abroad, and that the public is continually able to evaluate the implications of changing developments;
- help to make fully effective the coordination of energy-related programs initiated by governments, industries, utilities and by others, in all parts of Canada;
- assist members of the public to appreciate how their active, responsible participation in energy-related activities contributes to a satisfactory energy transformation; and
- ensure that up-to-date information is always available to participants in all parts of the country to permit meaningful discussion, debate, evaluation and participation in energy-related programs.

Recommended actions:

(1) (a) priority be given to the establishment of comprehensive information and communications programs to achieve widespread public participation in the energy transitions, and to permit widespread public understanding of, and support for, those processes;

(b) the information and communications programs include widespread, active exchanges of information to ensure the coordination of program initiatives; and

(c) a national energy secretariat be established as an information utility to all participants -- to receive, organize, analyze, and make available information on energy-related activities in Canada and abroad; that a World Energy Watch program be a part of the information assembly.

(2) (a) the information and communications programs make full use of "Energy State of the Nation" reports designed to keep Canada's energy future a matter of first importance on the agenda of the nation; and

(b) the State of the Nation reports, and other information and communication activities be supported by a set of long-term energy targets and objectives, interim performance targets and indicative timing and staging of programs, processes of audit, evaluation, and program revision, all of which to incorporate public discussion, debate and participation.

(3) (a) the information and communication program be fully supported by widespread analytical activities, these to include, for example, national energy budgets, national energy accounts (analagous to the national income and expenditure accounts of the gross national product), supporting energy-related analytical models and energy/economic/social accounts and analytical models; and

(b) all of the reports, accounts, models and targets of (2) and (3) to have provincial and regional components as appropriate.

(4) The information and communications programs to benefit from the participation of committees, task forces and groups which are continually investigating, recommending and implementing various parts of the national energy program; for example, significant inputs would come from those task forces and committees which are brought together within the five sets of programs of these Recommended Actions and of the related Strategic Issue Areas (identified in Appendix 3 of the report); a full set of media presentations and educational programs be included.

National Space Heating Program

Program objectives:

- implement and extend programs which, over the long-run, will increase overall heating efficiency by 50 per cent; and
- implement and extend programs to virtually eliminate oil from space heating by substituting natural gas, electricity, renewables and byproduct heat, co-generation and district heating, as appropriate in the different regions.

Recommended actions:

(1) To improve space heating efficiency: present programs, including insulation and other retrofitting be vigorously pursued and extended; energy efficient building standard codes be adopted for all new buildings.

(2) Recently instituted programs to establish minimum standards of efficiency for new heating equipment, and programs for improving the efficiency of existing equipment be vigorously pursued and extended.

(3) A national space heat audit be instituted to identify local and provincial opportunities to use local and other Canadian-supplied fuels, with particular emphasis on natural gas, district heating, co-generation, renewables, byproduct energy and electricity.

(4) Programs be instituted, initially as pilot and demonstration programs, to make use of multiple-fuel possibilities, with particular regard to seasonal and local availability.

(5) Programs be instituted, initially as pilot and demonstration programs, to demonstrate the feasibility and advantages of extensive heat storage (particularly seasonal) and heat transfers.

(6) (a) institutional and regulatory capabilities be established to deliver heat rather than a specific fuel; and

(b) where possible, attempts to accomplish the objective of (a) be made through existing utilities or other existing institutions.

Consolidated energy supply — the natural gas component

Program objective:

- Establish and maintain, in a flexible, dynamic way, an appropriate mix of indigenous energy supplies for Canada as a whole, and for each province and region.

The programs for new energy balances are designed to exploit the energy which we can have in the future rather than what we have been accustomed to having in the past. To integrate new supply components into the new energy balances involves the elimination of apparent conflicts in the marketplace (e.g., residual oil and natural gas; electric utilities and co-generation). It thus requires the maximization of supply complementarities by, among other things, introducing the necessary institutional and regulatory changes, ensuring full industry and public participation, and facilitating the price, financial, manpower, equipment and materials support adjustments. The energy balancing process will continue to rely upon international trade in energy resources and in energy-related goods and services.

A start on the Consolidated Energy Supply Program can be made with any resource, or by actions taken on many of them at the same

time. An illustration is given here of how natural gas might be used as a strategic starting point into the Consolidated Energy Supply Program.

Recommended consolidation steps

(1) A capability be established to provide a 30-year, assured supply of natural gas for an increased market, particularly in central and eastern Canada, by:

   (a) ensuring that the market facilities and appropriate prices and institutions are present to permit the penetration of natural gas into those markets;

   (b) ensuring that supplies and pipelines are available to cascade gas into the market -- perhaps first from the enlarged, conventional Alberta reserves, then from new gas formations in western Canada, Mackenzie Delta and Beaufort Sea, East Arctic (LNG tankers and/or a natural gas pipeline), possibly from Labrador and other offshore east coast; and

   (c) possibly supplementing the above natural gas supplies, for a time with imported LNG, with SNG, coal gas and hydrogen.

(2) The incremental gas supply be integrated with indigenous renewables, co-generation and byproduct heat, district heating, tidal and wave power, other electricity and regional coal.

(3) Complementary natural gas and residual and heavy oil programs be developed by changing refinery processes and possibly by exporting temporarily surplus petroleum products and natural gas.

(4) The natural gas supplies and residual oils be integrated with the heavy oil programs, and with production from the oil sands and frontier regions.

(5) The oil sands production be integrated with the coal requirements of the oil sands, possibly introducing organic-cooled nuclear reactors for high-pressure steam for the oil sands and heavy oils.

(6) The above coal requirements be assessed in conjunction with thermal coal for electricity generation, for SNG and liquid fuels production, and coal for metallurgical and other industrial uses in Canada and for export.

(7) The thermal-electric coal requirements be assessed in conjunction with hydro, nuclear, biomass, wind, solar, co-generation and other electricity generating capabilities.

(8) From the above, the best combinations be established to meet the greatly changed energy needs of the provinces, regions and the nation, taking into account also international energy relations and the economic and social opportunities in each region.

The natural gas supply capability

Program objectives:

- increase natural gas production by approximately one-third, to supply at least 3 200 billion cubic feet a year by 2000, and increase that production further to 2025;
- develop additional markets, particularly in central and eastern Canada, on the basis of a 30-year assured supply of natural gas as provided by the increased production; and
- integrate the gas supply with new patterns of energy use and complementary sources of supply.

Recommended actions:

(1) Ensure that the requisite natural gas supply is available over a 30-year period; increase efforts to establish long-term production and deliverability, based first upon proven conventional natural gas reserves; then, as feasibility is demonstrated, from new types of formations and deposits in western Canada; from the northern frontier regions and the offshore east coast.

(2) Encourage further exploration to identify natural gas reserves; provide for the necessary financial participation and, as necessary, for advance purchase and storage, short-term gas exports and interruptible domestic supply arrangements.

(3) Provide the complementary delivery systems such as the extension eastward of the natural gas pipeline, western Arctic and eastern Arctic pipelines, LNG facilities as required.

(4) Ensure that distribution and consumer facilities are developed to use the additional supplies of natural gas, and that pricing policies and institutional arrangements are fully supportive of using the additional natural gas in ways complementary to the other, particularly indigenous, energy supply capabilities.

(5) Assess the additional supply capabilities from the temporary importation of LNG, the production of SNG, coal gas and hydrogen.

Recommendations as a whole

The recommendations of the Futures report are designed to extend current initiatives and to ensure that long-term future energy transitions for Canada and for the world receive the highest possible priority in the nation's business. The recommendations are a comprehensive response to the long-term future. Taken together, they are intended to introduce new dimensions of: shared perceptions, comprehensiveness, information and participation; fundamentally different energy balances, economic and social opportunities.

6. CONCLUSIONS

The long-term energy situation in Canada and for the world will enter an extremely critical phase within the next 10 years, one capable of causing great economic and social disruption. A crisis likely will show up first in the world supplies and price of oil. Adjustments to meet those problems will cause further major stress. At best, the adjustments will require 20 to 30 years even if concerted action is begun right away.

Canada, with its vast energy resources, can make a contribution to easing the world energy difficulties by implementing plans and programs to achieve sustainable self-reliance in energy -- to call upon world energy supplies only when their availability and prices make that a preferred course of action, but not to be dependent on world energy.

Important beginnings have been made in Canada to achieve a greater measure of self-reliance, but the probable situation beyond 1990 could still leave Canada too dependent on imported oil, especially to meet the energy needs of central and eastern Canada. Four things are needed at this time to avoid that vulnerability:

- an acceptance by all Canadians that the future energy situation could indeed cause us serious distress and that it requires drastic action now;
- a significant reduction in the rate of growth in energy demand and substantial transformations in the patterns of energy use to match the energy supplies which will become available from Canadian resources;
- great efforts to increase Canadian energy supplies from all practical sources, and to do so economically and efficiently; and
- a clear understanding that the above programs are aimed at new energy balances which essentially eliminate any dependence on imported oil, while leaving Canada still an active participant in trade, finance and other international activities related to energy, and which achieve satisfactory economic performance and enhanced personal and community well-being.

The above programs will take us progressively through stages of transition to self-reliance in energy by the year 2000 -- a self-reliance which, with further adjustments, can be sustained to 2025 and beyond. The magnitude of the effort, starting now, will be greater than any previously undertaken by Canadians in peacetime. The rewards of success will be great. Failure could shake the foundations of our society.

Although many of the efforts are unique to a particular province or region, success ultimately requires a national approach and a high sense of national purpose.

The tasks represent new forms of decision-making and of social organization. We are required now to build into our decisions and our actions far more concern for the third dimension of time -- the long-term future. All of the available time will be needed if we are to make the transformations successfully. Failure can be triggered by inaction -- by a sense of public complacency, or an inability to organize the effort. If we proceed to meet the challenges successfully, new opportunities will continually open up for Canadians in all parts of the country.

The recommendations and the report deal with a future stretching out for 50 years. That is not a remote future. It begins now. To assume that concerted effort on these recommendations and on a national energy program can be set aside for five or ten years will be to ensure that Canadians will face greater difficulties of adjustment and greater economic and social stress. To build now systematically upon the initiatives which already are being taken can provide a new national purpose centred on one of the most dynamic, potentially disruptive or potentially enriching forces in Canada's future.

Annex 1
SUMMARY — AN ENERGY STRATEGY FOR CANADA, 1976

The national energy strategy that the federal government has adopted is directed at minimizing the extent to which Canadians rely on imported oil. The objective of the strategy is energy self-reliance.

In support of the self-reliance objective, the Government of Canada identified in the publication, "An Energy Strategy for Canada", nine major policy elements, and has adopted a number of specific energy-related targets. The policy elements are:

- appropriate energy pricing;
- energy conservation;
- increased exploration and development;
- increased resource information;
- interfuel substitution;
- new delivery systems;
- emergency preparedness;
- increased research and development; and
- greater Canadian content and participation.

The major energy-related targets adopted by the Government of Canada are:

- to move domestic oil prices towards international levels; and to move domestic prices for natural gas to an appropriate competitive relationship with oil over the next 2-4 years;
- to reduce the average rate of growth of energy use in Canada, over the next 10 years, to less than 3.5 per cent per year;
- to reduce Canadian net dependence on imported oil in 1985 to one-third of our total oil demands;
- to maintain self-reliance in natural gas until such time as northern resources can be brought to market under acceptable conditions; and
- to double, at a minimum, exploration and development in the frontier areas of Canada over the next three years, under acceptable social and environmental conditions.

Annex 2
CONTENTS — ENERGY FUTURES FOR CANADIANS, 1978

(Canada, $5.00; other countries, $6.00). Available from Government Publishing Centre, Ottawa, and selected bookstores.)